S. A. E. JOURNAL

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Summer Meeting Arrangements

Reservation Blanks To Be Mailed April 10—Seven Technical Sessions Planned

HOTEL reservation blanks for the 1928 Summer Meeting at Quebec will be mailed about April 10. Members should not attempt to make reservations direct with the hotel, as this will entail a delay inasmuch as such reservations would be forwarded to the Society. All reservations, after being recorded at the Society office, are forwarded to the Chateau, the more desirable rooms being assigned in the order in which the reservations are received.

A supplement in colors, showing the Chateau Frontenac as it appeared from the Lower City to the artist, will be found in this issue of THE JOURNAL. The dates of June 26 to 29 have been marked in red as a reminder that the 1928 Summer Meeting, the first S.A.E. meeting ever held outside of the United States, will be held on these dates.

Aside from the technical sessions and the technical and administrative committee meetings, arrangements are being made for the usual golf and tennis tournaments. Special sightseeing trips to Ste. Anne de Beaupre and the Montmorency Falls, 100 ft. higher than Niagara Falls, will be arranged, as will also other events which the splendid location of the Chateau and the facilities available make possible.

The Summer Meeting will be of special interest to the wives of the members, and various committees are being appointed to make their visit to Quebec especially worthwhile.

TECHNICAL PROGRAM TAKING FINAL SHAPE

Under the chairmanship of W. R. Strickland, the technical program is rapidly taking final shape. In addition to the Chassis, Transmission, Engine, and Research Sessions, sessions will be devoted to the discussion of body designing, transportation, and gear production. There also will be a general session at which the business aspects of engineering will be discussed.

Two papers have been definitely scheduled for the Transmission Session. One is by D. Sensaud de Lavaud, who will present in person a paper on the Swash-Plate Transmission which he has developed. His appearance will be doubly appreciated, as it will give the members an opportunity to discuss the interesting points which he made in his paper on Independently Sprung Front Wheels a Remedy for Shimmy, which was read at the last Annual Meeting in his absence by Mr. Strickland.

In the de Lavaud Annual Meeting paper it is pointed out that the riding-qualities which he has obtained with his design of vehicle are probably due more to the independent springing of the wheels than to the front-wheel drive. This is an interesting point which will doubtlessly be discussed in the paper at the Transmission Session at the Summer Meeting, which will be by Herbert Chase, of the Erickson Co., Inc. Mr. Chase's paper, dealing with the advantages and disadvantages of front-wheel drive, will summarize developments to date. The author will include the opinions of leading engineers in this Country who are being asked to submit their opinions anonymously.

It is of interest that tests which, as reported in the March 17 issue of *Automotive Industries*, were conducted at the laboratory of the Arts et Metiers, Paris, show a mechanical efficiency for the de Lavaud automatic transmission varying from 80.1 to 89.3 per cent. Twenty-nine distinct trials were made under the control of Government engineers. The maximum efficiency of 89.3 per cent was obtained when transmitting 33.8 hp. and reducing the speed from 1493 to 270 r.p.m., while the minimum observed 80.1 per cent corresponded to the transmission of 20.6 hp. with a reduction from 1517 to 207 r.p.m.

TRANSMISSION DESIGN

The problems of design and production of gears and transmissions will be closely interwoven at the Transmission Production Session. H. L. F. Orcutt, of The Gear Grinding Co. Ltd., of Birmingham, England, will present the first paper, the subject being Ground-Gear Production and Gearbox Design. His paper will contain many valuable suggestions for American motor-car engineers regarding gear-grinding methods for quantity production. It will also cover the design of splined shafts, ball bearings, and transmission housings.

The second paper at this session will be by Charles H. Logue and R. B. Fehr, of the Copland Gear Lapping Syndicate, and will discuss a new method of precisioning gears which it is thought will revolutionize transmission-gear production. The session should prove of great value to all engineers interested in transmission problems. The papers will be available in preprint form for distribution at an early date so that members will have an opportunity to prepare discussion for this session.

SPECIAL TRAIN AND CUSTOMS SERVICE

With the cooperation of the Canadian Pacific Railroad, excellent special-train and car service is being arranged for the Summer Meeting. The special trains from Detroit and New York City will make especially fast time and, where possible, the special cars from other cities will be attached to the special trains. So that sufficient train equipment may be reserved by the railroads, it is necessary that members notify the Society of the reservations that they desire.

Customs inspection of the members' hand baggage will be made en route, and special customs service will be available at the hotel in Quebec for inspecting trunks shipped direct. This service will be available on the return so that trunks can be inspected at the hotel and shipped direct to their destination. Exceptional service on the part of the railroad and the Chateau has been assured.

S. A. E. Meetings Calendar

Summer Meeting

June 26 to 29, 1928

Chateau Frontenac, Quebec

Buffalo Section Meeting—April 3, 1928

Production Methods—Charles Ekdahl, Pierce-Arrow Motor Car Co.

Chicago Section Meeting—April 10, 1928

Development of Aluminum for Automotive Purposes—R. S. Archer, Aluminum Co. of America

Cleveland Section Meeting—April 9, 1928

The Air Cruiser—Thomas M. Finley

Detroit Section Meeting—April 2, 1928

Laboratory Instrumentation—Ferdinand Jehle, White Motor Co.

Detroit Section Meeting—April 17 and 18, 1928

Aeronautic Division

See p. 487 for announcement

Detroit Section Meeting—April 23, 1928

Body Division

Trend of Design—H. A. Brunn, Brunn & Co., Inc.

Indiana Section Meeting—April 12, 1928

Piston-Rings—Ralph Teetor, Perfect Circle Co.

Metropolitan Section Meeting—April 19, 1928

Truck Meeting—A gathering of chief engineers of motor-truck companies

Milwaukee Section Meeting—April 4, 1928

Steering-Gears—F. F. Chandler, Ross Gear & Tool Co.

New England Section Meeting—April 11, 1928

The Most Powerful Aircraft Engine in the World—L. M. Woolson, Packard Motor Car Co.

Northern California Section Meeting—April 12, 1928

Problems of Maximum Range in Airplane Design—Dean Baldwin

M. Woods, University of California

Superchargers—J. Milton Davies, research engineer

Fans and Air-Flow through Radiators—Carl J. Vogt, research engineer

Pennsylvania Section Meeting—April 17, 1928

Traffic Regulations—Miller McClintock, Albert Russel Erskine Bureau for Street Traffic Research

Southern California Section Meeting—April 13, 1928

Chassis Lubrication—N. C. French, Union Oil Co.; Harold T. Ramsay, Standard Oil Co.; A. H. Walker, Associated Oil Co.; Jack French, Richfield Oil Co.; D. R. McBryde, McBryde Lubricating Sales Co.

Washington Section Meeting—April 17, 1928

Racing and Results—Wade Morton, Auburn Motor Co.

Chronicle and Comment

Detroit Section Divisions

ORGANIZATION of a Body Division on Feb. 13 and of an Aeronautic Division on Feb. 27 by the Detroit Section marks a new departure in Section activities. An account of the forming of the Body Division was given in the March issue of THE JOURNAL, p. 392.

Thus the Detroit Section pioneers a movement that reflects the growing importance of body and of aeronautic engineering as branches of automotive engineering. So diversified is the field represented by the Society and so rapid are the developments in this field that some of the larger Sections have found that one general monthly meeting does not afford sufficient opportunity for discussion of the many problems in which the members are vitally interested.

Aeronautic Standards Session on April 18

ENGINEERS and executives of airplane and airplane-engine companies and of allied industries are invited to attend the Standards Session to be held on April 18 at the Book-Cadillac Hotel, Detroit, during the 2-day Aeronautic Meeting at the time of the All-American Aircraft Show. Details of the plans for this meeting will be found in an article under Standardization Activities on p. 480.

Detroit Aeronautic Division Plans Meeting

AN interesting 2-day program has been outlined for the first meeting of the Aeronautic Division of the Detroit Section. This event, which has been scheduled for April 17 and 18, during the week of the All-American Aircraft Show, is under the direction of L. M. Woolson, Chairman of the Division, and William C. Naylor, Chairman of the Division Meetings Committee. Advance details regarding the nature of the program planned may be found on p. 487 of this issue of THE JOURNAL.

Operation and Maintenance

THE greatest needs of the operation and maintenance industry, said Glenn S. Whitham, at the March Meeting of the New England Section, are for better men and for more and better organized effort, as through the Society and its Sections, to throw light upon maintenance problems by free interchange of experience and knowledge. Engineers and executives in the fields of designing, production, operation and maintenance should realize more and more the advantages of such interchange of ideas.

Send in Your Reservations

HOTEL and special-train reservation blanks for the Summer Meeting, June 26 to 29, at Quebec, will be mailed to the members early in April. All desirable rooms will be assigned by the Chateau Frontenac in the order in which the reservations are received. Although the view is superb from all the outside rooms in the Chateau, the rooms facing the river are the most desirable, as they give a panoramic view of the Isle d'Orleans to the northeast, on the hills to the north of which can be seen the club house of the Quebec Golf Course, of Levis on the opposite shore, old Quebec at the foot of the cliffs, and the citadel to the southeast.

The 1928 Summer Meeting seems destined to be one of the most interesting ever held, not only because of its being held in the only city on this Continent which has a truly European character, but because of the technical program that is being arranged by the Summer Meeting Committee under the chairmanship of W. R. Strickland, and the social program which has been decided upon.

Members Invited to Joint Meeting

AN invitation to interested members of the Society to attend a joint meeting with the motor transport division of the American Railway Association and the Railway Supply Manufacturers Association has been received from Secretary G. M. Campbell, of the motor-transport division, on behalf of Chairman A. P. Russell.

This division of the American Railway Association was organized at Chicago last January, at which time it was decided to hold the next regular session in Atlantic City, June 21 to 23, at the Hotel Traymore.

It is proposed to hold the joint meeting with members of this Society and of the Railway Supply Manufacturers Association on the last day, June 23, to discuss matters of mutual interest. The meeting is to convene at 10 a.m. As this date comes just 3 days before the opening of the Summer Meeting of the Society in Quebec, members interested in coordination of rail and highway transportation may find it convenient to combine attendance at the Atlantic City joint meeting with the trip to Quebec.

Part II of 1926 Transactions

MEMBERS will receive shortly an order blank for Part II of the 1926 TRANSACTIONS. This Part, which it is expected will be issued in approximately 6 weeks, will be a volume of over 1000 pages containing papers presented at the 1926 Semi-Annual, Aeronautic, Production, and Transportation Meetings of the Society; also papers presented at Section Meetings and contributed articles that were published in THE JOURNAL from July to December, 1926, inclusive. It comprises a total of 41 papers and articles together with the discussion of the former. An order blank covering this Part of TRANSACTIONS was printed in the March issue of THE JOURNAL on p. 92 of the advertising section, and the additional blank, which will be sent out shortly, is for the convenience of those members who either overlooked the blank in the March issue or neglected to fill it out. As volumes of TRANSACTIONS are now sent only to members ordering them at the nominal price of $2 per Part and the printing order will be based on the number of orders received, members who do not place their orders prior to May 1 may be unable to obtain copies.

For the convenience of members who wish to receive Parts of TRANSACTIONS regularly in the future as issued without the necessity of placing a separate order, space is provided on the order blank for the placing of a standing order. Members who make this request will receive Parts of TRANSACTIONS as they are issued in the future, payment at the rate of $2 per Part to be made upon presentation of a bill prior to publication.

Future of Canadian-American Aviation[1]

By J. A. Wilson[2]

THE North American continent presents the greatest field in the world for the development of air-transport lines. North of the Mexican border lies an area of 6,000,000 square miles in which there is but one international frontier. Its inhabitants, numbering about 130,000,000, spring largely from common stocks. We speak a common tongue, share a common history and literature, and, though we differ in our forms of government, our civilizations are based on the same essentials. Our lot lies in perhaps the most favored portion of the world, and our countries are blessed with natural resources unequalled in variety and profusion.

The advent of mechanical transport has wrought a great change in our habits. With the building of the railways, the organization of ocean travel, the advent of the motor-car, and the building of good-road systems, travel at home and abroad is now possible for the average man and his family. In North America practically every family owns its motor-car and travel has been brought within the reach of our humblest citizens. Aviation adds another means of transport which will mean a still greater extension of the habits of travel. Natural obstacles mean nothing in the air, and the speed, comfort and convenience of travel by air will, without doubt, send our rising generation still further afield as the organization of ground facilities is extended and the efficiency of aircraft increases.

In the United States the Post Office Department took the lead in organizing air routes. Its sole interest was the carriage of mails and, until the contract system was instituted recently, there was little or no organized passenger traffic. Under the contract system there has been a great advance. Contractors are free to cater to other forms of traffic and there is every prospect that in a very short time travel by air throughout the United States will become common and that all the principal centers will be connected by regular air services for the carriage of mails, passengers and express matter.

International Air Travel Will Increase

In Canada, our air development has been on altogether different lines. Our flying has been mainly for the conservation of forests and the exploration and development of districts hitherto inaccessible. Our smaller population, greater climatic difficulties and the financial stringency of the post-war period have tended to make progress in the establishment of regular airways slower. We are now facing the problem, however, and a few years undoubtedly will see the establishment of trunk lines for air communication throughout the Dominion.

We may confidently assume that, provided proper facilities are established, international traffic by air between Canada and the United States will increase in the same proportion as our domestic air traffic, and that trade and travel by air will flow between the two countries just as it flows today on the ground. Interchange of traffic between the two countries by air is therefore a matter which calls for close attention from our respective governments and those organizations in both countries interested in the development of aviation.

Our frontiers, happily, present no hindrance to the passage of traffic, and the magnitude of this interchange of traffic is astonishing. Our Post Office authorities state that there is an average daily letter mail between the two countries of 500,000 letters alone. Statistics furnished by the railways showed that in 1926 over 2,300,000 people booked tickets from the United States to Canadian points, and it is estimated that the number of passengers booking from Canada to points in the United States was 1,700,000. The number of automobiles entering Canada from the United States was, in 1926, more than 2,000,000. Canadian cars entering the United States in the same year numbered 350,000.

Canada and the United States are each other's best customers. In the 12 months ending Oct. 31, 1927, of the total of Canadian foreign trade of $2,323,000,000, no less than $1,195,000,000 was with the United States. The Canadian share of the United States' total foreign trade of $9,183,000,000 was $1,303,000,000, or $50,000,000 more than that of your next best customer, Great Britain.

These few figures give some indication of the trade that may be served by air-lines between the two countries. Good communications are the life-blood of that trade. Just as our railway, good-road, canal, telegraph and telephone systems are the equal in efficiency of those of any country in the world, there can be little doubt that our airways also will be fully developed.

Government of Internationl Air Traffic

International traffic by air is governed in Europe by the International Convention for Air Navigation. The first two articles of the convention are significant. Article 1 recognizes that every power has complete and exclusive sovereignty over the air above its own territory, and Article 2 provides that each contracting state shall, in time of peace, grant freedom of innocent passage through its air space to the aircraft of other contracting states, provided the conditions of the convention are observed.

Both Canada and the United States were signatories to the convention and were represented on the subcommittee of the Peace Conference at Versailles which drew it up. Canada subsequently ratified the convention and is bound by it, but the United States has not yet done so. This is immaterial, since every contracting state is free to enter into such other international agreements as may be necessary, provided the terms of the convention are not infringed.

An informal agreement between the United States and Canadian Governments relative to international flying has existed since April, 1920, but until the formation of the Bureau of Aeronautics in the United States Department of Commerce and the passing of legislation for Federal control of interstate and international flying

[1] Address delivered at aviation session at the 1928 Annual Meeting.

[2] Controller of civil aviation, Royal Canadian Air Force, Ottawa, Canada.

in 1926, there was no Federal department or law regulating civil aviation, and temporary expedients were followed. These have gradually become regularized and a system satisfactory to the authorities of both countries is now in force. Under this system it is mutually agreed that aircraft registered and licensed as airworthy by the Bureau of Aeronautics of the Department of Commerce, in the United States, and the Department of National Defence, in Canada, and bearing nationality and registration marks, may cross the border and fly in each other's territory provided their pilots are duly qualified and licensed and that they report to the customs and immigration authorities on entry and before leaving foreign territory.

Today, international traffic by air is unorganized; it is almost wholly private flying for pleasure. This traffic will increase greatly as aircraft come into common use. Licensed pilots flying registered aircraft entering Canada for such purposes need only notify the Collector of Customs at the most convenient point of entry of their probable time of landing, so that arrangements may be made in advance for the inspection and entry of the plane. As air traffic develops, however, and regular services come into being, more formal arrangements will be necessary, and it is not difficult to visualize the establishment, within a few years, of public airports in the principal cities, where special customs facilities will be provided for the entry and clearance of aircraft.

J. A. WILSON

The lines of air traffic probably will follow routes already well defined. The main routes will be, as now, along the Atlantic Coast to St. John's and Halifax; through northern New York State by the Hudson River Valley and Lake Champlain, between New York City, Montreal and Quebec; across the St. Lawrence River from New York State into eastern Ontario to Brockville, Kingston and Ottawa; from Buffalo into western Ontario, Toronto and Hamilton; from Michigan through Detroit to Windsor and London; across the upper lakes at Sault Ste. Marie into northern Ontario; from Minneapolis to Winnipeg; from the western prairie States to Regina, Moose Jaw, Lethbridge and our prairie provinces; and, finally, from Seattle and Portland to Vancouver and Victoria on the Pacific Coast. Customs facilities will be required at these key points, where the main lines of air travel are likely to cross the border.

Generally, northern and eastern Canada is a paradise for flying-boats in summer, and access to every part is easy by such means. When proper ground facilities are established, flight by airplane through the St. Lawrence Valley and access to it from the south will present no difficulty. Those who wish to penetrate further into Canada must use seaplanes, as flying-fields cannot be found in the northern forest and lake country. Our prairie provinces between the international border and the Saskatchewan River provide ideal flying conditions everywhere very similar to those in your own great central plain. The Rocky Mountains present a common problem on both sides of the border, but on the Pacific Coast passage is easy by flying-boat.

The winter problem is more difficult and the ingenuity of our designers will be required to solve the problems of ski-float and ski-wheel undercarriages. Good landing-grounds for aircraft on skis will be found everywhere in winter since the open fields and the surfaces of all our lakes and rivers are available.

The ski-wheel undercarriage is a pressing problem, not only in connection with international flying, but for flying within our own borders, since climatic conditions vary greatly. The ski-float will not affect international services to the same extent, and it is a problem more peculiarly our own.

Other technical questions will require close attention, not only from our respective Governments, but from our aircraft operators and manufacturers. The most important and pressing of these is a recognition of equal standards of airworthiness for aircraft. The Bureau of Aeronautics of the Department of Commerce and our own Department of National Defence are already in close touch with this important feature. While it is easy to arrive at an agreement on factors of safety in the design of aircraft which shall be insisted on, the inspection of the material used in the construction is a much more difficult question and one that requires the most careful handling. Neither country can afford to see the commercial aircraft of the other built to different standards and yet admitted to engage in common international traffic.

This problem is much more difficult of solution than the seemingly more formidable one of arriving at an international agreement covering flying or the machinery by which aircraft may make their entry into a foreign country. It is one in which I ask the Society to lend its aid. It is a wholly technical problem, that of balancing safety in the air, without which no company can hope to operate at a profit, with the cheap and rapid construction of aircraft on which the spread of aviation depends. The manufacture of aircraft must not be tied up by needlessly stringent specifications, but it must, in the interest of everyone, enable the operators of aircraft in public services to assure their customers of safe, convenient and speedy transportation.

Present regulations of the two countries permit of the entry of the aircraft of each to the other's territory but not the carriage of goods and passengers between points in that territory. The equipment of international airways with adequate ground facilities need present no difficulty. All that will be required is an agreement as to the best line of travel to the point of crossing the frontier. Lighting can then be installed by each country up to the border. Radio directional-finding beacons can be installed on the same principle. There is co-operation between so many of our services today on the border that there need be no doubt that the air authorities will find a solution to their border problems as they arise.

Personal Notes of the Members

Brandt Goes with Autocar

A. J. Brandt, formerly vice-president of the Oakland Motor Car Co., has been retained as a consulting industrial engineer by The Autocar Co., Ardmore, Pa., to coordinate sales, financial engineering and all manufacturing operations, including the layout, processing, assembling and machining methods, and the purchase of materials and equipment.

After his graduation from the Case School of Applied Science, Mr. Brandt worked for several years on construction jobs, and in 1916 became resident engineer with E. I. du Pont de Nemours & Co., at Philadelphia, in charge of plant construction and maintenance. In 1918 he was sent by this company to take charge of the construction of the mechanical division of the Old Hickory powder plant at Nashville, Tenn. Later he went to St. Louis as resident engineer to take charge of the erection of the Chevrolet body plant, powerhouse and assembly plant for the General Motors Corporation. After being stationed, during 1920, at Syracuse, N. Y., to erect a new plant for the Brown-Lipe-Chapin division of the General Motors Corporation, he was transferred to Janesville, Wis., as works engineer of the Samson Tractor Division of the same corporation, later becoming production manager of the entire division. In 1923 the Fisher Body Corporation employed his services in building and operating a body plant at Janesville. During the following year Mr. Brandt was sent to Oakland, Calif., to erect a new malleable-iron factory for the Pacific Malleable Castings Co. In 1925 he was transferred to the Oakland Motor Car Co., at Pontiac, Mich., where he became vice-president in charge of operations.

Mr. Brandt has been a member of the Society since 1926.

Younger Writes About Ford

An article entitled How Henry Ford Gets Phenomenally Low Manufacturing Costs, which appeared in the January issue of *Manufacturing Industries*, states that Henry Ford, in starting the manufacture of the Model-A car, has again shown the soundness of a definite group of manufacturing fundamentals. John Younger, who is the author of the article, names and discusses these basic ideas which, he says, no other single manufacturing enterprise has ever carried to such lengths in practical application, and in addition he interprets for his readers the principles that he discusses. This article is the first of a series by Mr. Younger, the second having appeared in the February issue of the above-mentioned publication under the title, How Henry Ford's Material Control Reduces Production Costs. Mr. Younger is eminently qualified to write such a series, as he has known the Ford organization for many years and has brought his knowledge of current developments uptodate by recent visits.

Mr. Younger has been actively connected with the automotive industry ever since his graduation from Glasgow University. Prior to coming to this Country in 1910, he was employed by the Arrol-Johnston Motor Car Co. and later by Dennis Brothers, Ltd. His first connection in this Country was with Howard E. Coffin in designing motor-trucks, after which he became general factory manager of the Cass Motor Truck Co. In 1911 he accepted a position with the Pierce-Arrow Motor Car Co. He was chief engineer of its motor-truck department when he resigned during the war to enter the Quartermaster Corps of the Army, later becoming chief of the engineering division of the Motor Transport Service. After the Armistice, Mr. Younger held responsible positions with the Standard Steel Car Co. and The Standard Parts Co. Since 1925 he has been professor of industrial engineering at the Ohio State University. In 1923 he established *Automotive Abstracts*, a publication of which he is owner and editor.

Many articles by Mr. Younger have appeared in technical and trade papers, including the following in Society publications: Worm-Drive Truck Axles, in the S.A.E. BULLETIN, Dec., 1913, reprinted in TRANSACTIONS for 1914, and Retardation of the Automobile, in the S.A.E. BULLETIN, Jan., 1917, reprinted in TRANSACTIONS for 1917.

Elected a Member in 1911, Mr. Younger has participated actively in the work of the Society. He was a member of the Buffalo Section for 2 years and of the Cleveland Section for 6 years, serving the latter as Chairman in 1924. He has been at various times a member of the Truck Division of the Standards Committee, the Membership Committee, the House Committee, the Sections Committee, the Student-Group Subcommittee, the Production Advisory Committee, the Meetings Committee and the Publication Committee. He is at present chairman of the Publication Committee.

Changes in Motor Transport Division

Lieut-Col. Brainerd Taylor has been relieved from duty in the Philippine Islands and ordered to report to the Quartermaster General for duty. He will succeed Col. Frank H. Burton as chief of the Motor Transport Division, Transportation Service. Colonel Burton, who is due, under the Troop Duty Law, for duty with troops, has been a valued member of the Society and of the Washington Section since 1925, when he was elected a Service Member.

Colonel Taylor also was elected a Service Member in 1925. He was already well known to members of the Society because of a splendid paper, Military and Commercial Highway Transport, which he had presented at the Society's Automotive Transportation Meeting in April, 1923, and which was published in the May, 1923, issue of THE JOURNAL.

Ver Linden Joins Jordan

Edward Ver Linden on March 1 became chairman of the executive committee and member of the board of directors of the Jordan Motor Car Co., Inc. He brings to this important connection certain outstanding abilities that have characterized him during his long and successful experience in the automotive industry. After several years as vice-president and factory manager of the Michigan Auto Parts Co., he accepted a responsible position with the Buick Motor Co., later becoming president and general manager of the Olds Motor Works and subsequently holding a similar position with the Ver Linden Division of Durant Motors, Inc. For the last 3 years he has been president and general manager of the Peerless Motor Car Co.

Mr. Ver Linden was elected to membership in the Society in 1918 and has been an active Section member for several years, first in Detroit and later in Cleveland.

Leahy Opens Office as Consultant

M. J. Leahy has resigned his position as lubrication engineer with the Texas Pacific Coal & Oil Co., Fort Worth, Tex., and has become a consultant in mechanical and chemical engineering in Houston, Tex. He proposes to serve both the automotive engine builder and the oil marketer by acting as a confidential clearing-house for lubrication information.

Mr. Leahy was employed by Henry Ford & Son in 1918 in tractor experimental work and later was connected with

(*Continued on p. 18 of advertising section*)

Big Detroit Body-Division Meeting

Attendance of Nearly 500, Including Many Executives, Exceeds All Expectations and Enthusiasm Runs Rife

Great success for the new Body Division of the Detroit Section is indicated if the first post-organization meeting of the Division can be accepted as a criterion. This meeting, held on March 19, exceeded all expectations in attendance and enthusiasm. About 390 partook of the members' dinner and 490 heard a paper by O. T. Kreusser, of the General Motors Corporation, on the question, Do the 1928 bodies meet the requirements of the public from a practical viewpoint as determined by the man who tests them?

The paper was one of the most critical, suggestive and inspirational of all that have been presented at any Detroit meeting this season, reports B. J. Lemon, vice-chairman of the Section, and the audience rose and cheered the speaker before and after its delivery. And more spirit, in general, was shown at the meeting than at any previous meeting. More chief engineers and executives were in attendance than at former meetings, including a number who had not attended previous sessions of the Section during the 1927-1928 season.

The newly elected Division Chairman, William N. Davis, body engineer of the Cadillac Motor Car Co., and the assistant chairman of the Body Division Meetings Committee, Carl B. Parsons, president of the Parsons Mfg. Co., conducted the meeting in its entirety. Entertainment, consisting of dancing which represented different stages of body construction was a novel feature that afforded much enjoyment, as well as several musical numbers rendered by an orchestra and male trios.

Twins Stir Fishleigh To Expatiate

Some of the enthusiasm occasioned by and left over from the meeting bubbled over in letters from Section Chairman Walter T. Fishleigh, quoted in part below, and from the assistant secretary of the Section, reproduced on the following page. Writing to C. B. Whittelsey, Treasurer of the Society, Mr. Fishleigh said:

> Don't ask me to try to describe the entertainment, or the enthusiasm, or the spirit at this meeting. It's like mountain scenery; you have to see it to believe it. All I can say is that I believe, with the Body Division's help, we put over one of the best meetings the Detroit Section has had this year, and I really believe that this new body activity will mean 100 new members for the Society by November next. Of course, you will appreciate that to organize this Body Division and line it up with the above results has taken a lot of organization and attendance at meetings by Detroit Section officers and committees, but we have forgotten all the hard work in the realization of this result.
>
> Now about the Aeronautical Division. At the organization meeting, Monday, Feb. 27, there were some 280 at the dinner and about 350 at the meeting, and the whole thing went off with a bang, fully as enthusiastically and we believe with fully as satisfying results.
>
> Look at the line-up of Division officers for the two divisions, which means success and continued high speed activity through next year:
>
> BODY DIVISION
>
> Chairman, Bill Davis, Cadillac
> Chairman Meetings Committee, Carl Parsons
> Rhein—Packard
> Votypka—Murray Body
> Webber—Graham-Paige
> Wittkowsky—Fisher Body
> Woina—Budd Mfg.
>
> AERONAUTICAL DIVISION
>
> Chairman, Capt. Woolson, Packard
> Chairman Meetings Division, Bill Naylor, Stinson
> Ralph Upson—Aircraft Development
> Bill Stout—Stout Air Services
> Ivan Driggs—Driggs Aircraft
> Jack Whitaker—Tide Water
>
> You know the old adage: There are two things in life we are never prepared for—and those are TWINS. I told the body bunch at the last meeting that I believe in this respect the Detroit Section had set a world's record, for in the last 2 months we have given birth to two mighty big, vigorous, howling twins, and we were not only prepared for them but welcomed them with open arms and, being unable to get away from the Detroit dynamic commercial spirit, immediately put them to work.

Very attractive announcements of the Body Division and Aeronautic Division Meetings were sent out as part of the measures taken to arouse interest. The front-page design of the Body Division announcement, which referred to the March 19 meeting as the "Coming-Out Party," is reproduced at the bottom of this page.

Kreusser Makes Strictures on Bodies

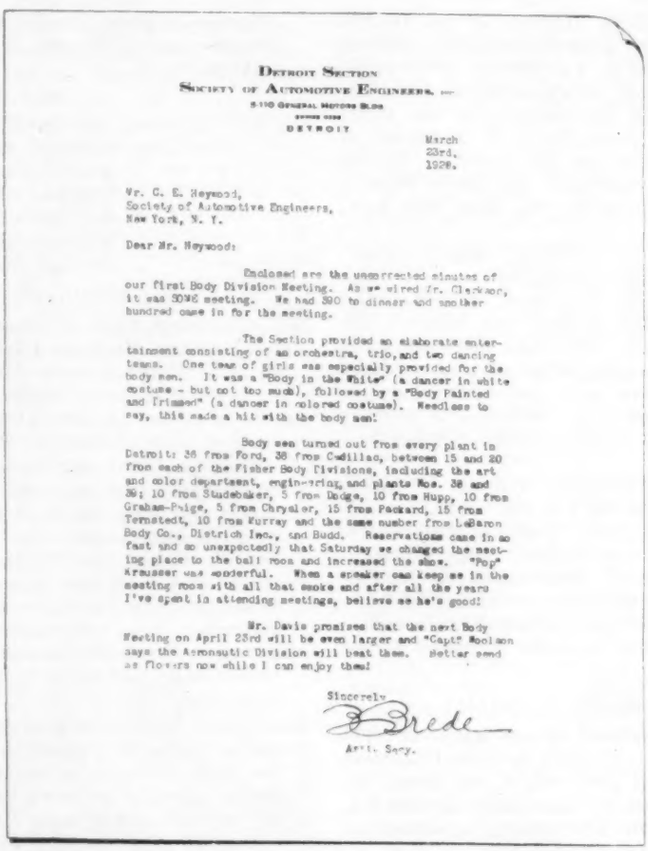
Constructive criticism of body design and construction was given in an absorbing talk by O. T. Kreusser, director of the General Motors Proving ground, who was given a rising salvo of cheers after answering a few questions on his subject just before adjournment of the meeting. His comments regarding bodies were based upon observations of the five-passenger sedan bodies on all the General Motors Corporation cars tested at the proving ground. His remarks were directed at the composite of bodies on all cars, the body for the average driver, and not at any individual body. Test drivers at the proving ground step from one car to another and ride in a great many different bodies on different makes of chassis in a short time, hence get different sensations than does the man whose driving is confined to one or two cars and who therefore becomes accustomed to them.

Although the body gives less trouble in keeping the car running on the road than any other major part of the automobile, it is the most obvious part and persistent petty annoyances caused by it cannot be tolerated. Tire troubles are accepted through long experience as something to be expected, hence do not annoy so much

as squeaks or out-of-order hardware in the body. We no longer tolerate door latches and doors that will not stay closed, because sometime in our experience, said Mr. Kreusser, we have had a body with doors that would stay closed, and could actually see through the windshield.

The Body Sells the Car

Good appearance was mentioned as the first requirement of a car. The next most important factor is driver and passenger comfort, particularly of the women. After comfort comes performance of the car, which involves getting it started, operating it over all sorts of roads in all kinds of weather, and eventually stopping it. Reliability, economy and durability are other important factors in the sale of cars. So we have changed from a group of engineers designing mechanical parts to the engineering function of designing beautiful, comfortable creations that are mechanically right so that they shall maintain the standard that has been set. We have reached the time, thinks Mr. Kreusser, when, instead of the chassis engineer presenting a design to the body designer for him to follow, the problem will be, and already is being, attacked the other way; the body engineer designs the esthetic features and the chassis engineer conforms the mechanism to those designs. This is because there no longer is any argument that the attractive, comfortable body that remains reasonably free from petty annoyances largely determines the success of any make of automobile.



Detroit Section
Society of Automotive Engineers, Inc.
5-110 General Motors Bldg.
DETROIT

March 23rd, 1928.

Mr. C. E. Heywood,
Society of Automotive Engineers,
New York, N. Y.

Dear Mr. Heywood:

Enclosed are the uncorrected minutes of our first Body Division Meeting. As we wired Mr. Clerkson, it was SOME meeting. We had 380 to dinner and another hundred came in for the meeting.

The Section provided an elaborate entertainment consisting of an orchestra, trio, and two dancing teams. One team of girls was especially provided for the body men. It was a "Body in the White" (a dancer in white costume - but not too much), followed by a "Body Painted and Trimmed" (a dancer in colored costume). Needless to say, this made a hit with the body men!

Body men turned out from every plant in Detroit: 36 from Ford, 38 from Cadillac, between 15 and 20 from each of the Fisher Body Divisions, including the art and color department, engineering, and plants Nos. 36 and 36; 10 from Studebaker, 5 from Dodge, 10 from Hupp, 10 from Graham-Paige, 5 from Chrysler, 15 from Packard, 15 from Ternstedt, 10 from Murray and the same number from LeBaron Body Co., Dietrich Inc., and Budd. Reservations came in so fast and so unexpectedly that Saturday we changed the meeting place to the ball room and increased the show. "Pop" Kreusser was wonderful. When a speaker can keep us in the meeting room with all that smoke and after all the years I've spent in attending meetings, believe me he's good!

Mr. Davis promises that the next Body Meeting on April 23rd will be even larger and "Capt" Nelson says the Aeronautic Division will beat them. Better send us flowers now while I can enjoy them!

Sincerely,
F. Brede
Asst. Secy.

Some uniformity should be reached in the matter of fundamentals pertaining to the human body, such as leg-room, head-room and height from the seat cushion to the roof. Great variation is found in different cars in front-seat width, width between the door post and the seat cushion, clearance between the steering-wheel and the garnish rail, head-room from the seat cushion to the roof, distance from the seat back to the rim of the steering-wheel, and distance between the bottom of the rim and the top of the seat cushion.

With all these differences, the same man is supposed to drive all the cars; that is, the cars as designed are sold for use by all men, the average man.

One very fundamental dimension is the distance in a line from the pedal touching the edge of the driving seat cushion and striking the seat back at the height of the shoulder. This distance ranges from 40¾ to 46⅛ in., and the difference is not accounted for by differences in wheelbase. Another dimension that has become exceedingly important is the height of the line of vision. Drivers' eyes average about 26¼ in. above the seat, yet in some cars the top of the windshield and the visor are below this height, so that the driver must slump down to look under them. Horizontal visibility has been improved but vertical visibility is neglected.

Designers do not agree as to the degree of seat angle. "One tilts you in a V so that you need to grasp the handles to pull yourself out, and another puts you on an incline that you cannot stay on," remarked Mr. Kreusser, bringing another of the many bursts of laughter which his hearers interspersed with his comments.

The speaker also directed his criticisms toward body hardware, the instrument board, the windows, "drumming" of the body, flexibility that results in twisted doors that will not close or open and so on. No relation exists between weight of the chassis and twisting of the car and body assembly, he said, and the wheelbase has very little effect on this. There is, however, a very direct relation between the torsional stiffness of a car and the amount of annoyance it gives the owner.

Commenting on squeaks, Mr. Kreusser said that no one ever told anyone else how to keep them out of a body and, to make matters more interesting, the bodies are upholstered in such a way that even the expert cannot get at the location of the squeaking part to fix it. Excessive flexibility of the front part of the car with relation to the driving seat, heat from the engine, cold drafts from the floorboards and around the windshield and doors, exhaust fumes, excessive vertical motion of the rear seat and many other things that affect the comfort of the driver and his passengers or have a psychological effect were touched upon.

Condition of a car and its body after a year's service was reviewed at some length, to the amusement of the audience.

As for the safety of bodies, Mr. Kreusser said that the average closed body, whether steel or composite, "is about as good a box to be in, if you want to loop the loop and roll over three or four times, as human ingenuity can devise." In the 10,000,000 miles of the test operating of cars at the proving ground, no driver has been killed or even seriously injured, although the drivers sometimes fall asleep and cars occasionally roll over, resulting in total wreckage of the body. Vertical location of the center of gravity has little bearing on the stability of the car, he said, owing to many other variables. In resisting collision, bodies are stiff structures endwise, but are frail against "side-swipes."

STUDENT BRANCH DISCUSSES TAYLOR

Three papers on Frederick W. Taylor and his contributions to industrial management were presented at the second meeting of the Society's Student Branch at the General Motors Institute of Technology, held on the evening of Feb. 24 at Flint, Mich. A dinner at the Marjay Grill preceded the meeting.

The papers presented were: Business before Taylor, by Arthur Krushensky; Taylor, the Man, by Gerald Chase;

(*Continued on p.* 484)

Civic Planning for Airports and Airways

By JOHN NOLEN[1]

AERONAUTIC MEETING PAPER

Illustrated with PHOTOGRAPHS AND DRAWINGS

IN the provision for air service throughout the United States the time is ripe for a frank stock-taking of existing conditions and a statement of the present and the probable future requirements of aviation. Problems of aviation are much like other broad city and regional planning problems, requiring study and mastery not only of the physical conditions, but also a firm grasp on their financial and economic relations under appropriate statutes, laws and regulations. Early study from this viewpoint will improve results and secure economy in planning, construction and maintenance.

Although aviation is a new and distinctive method of travel, with many conditions peculiarly its own, much can be learned from the history, the evolution and practical application of other means of travel—the railroads, trolleys, motor-vehicles and ships.

The first consideration which is particularly important in the study of airports is their location in a city: whether they should be as central as possible, or in the outskirts. When the railroad was in its pioneer stages, the aim was to get a central situation in a city for its station or terminal. In more recent times it has often been found better to locate stations farther from the center of the city. Examples of such locations are the newer stations in Kansas City and Detroit and the removal of the Pennsylvania terminal in Philadelphia from the heart of the city to West Philadelphia. Other semi-public and municipal buildings tend to decentralize, because of the increasing congestion and noise of the built-up sections of cities and because of the convenience of motor-vehicle transportation.

Another railroad policy which can be considered with profit is the union depot idea. Advantages of one or more landing-fields in a large city or metropolitan region, at which all aircraft would be served, need to be considered against those of separate ports or landing-fields for airplanes, for airships, for balloons and for seaplanes.

Do you know:

What city planning has to contribute to the success of the airplane?

Why airways are more nearly related to transportation by water than by land?

That the success of airports depends upon a close correlation with other forms of transportation?

That geography, climatology, topography, size, area, layout, boundaries and accessibility are only some of the factors to be considered in planning an airport?

Whether you want public or private ownership of airports?

What a National system of airways would really mean?

That the future of the airplane may be linked with either an increase of public nuisances or an extension of public service?

Whether airways should determine the location of airports, or vice versa?

Another point for profitable reflection is the correlation of different forms of transportation—railroad, highway and water. Heretofore this has not been well done, and the disadvantages of the existing unrelated, poorly coordinated systems of transportation have been very great. Planning for aircraft should be coordinated. Air navigation will not stand by itself, but will be used in conjunction with other means of travel on land and water.

Comparison with the automobile shows the probable effect of the increase in the number of aircraft in the future. The problem of the motor-vehicle, moving or parked, on the country highway or the city streets, was simple enough 20 years ago when there were less than 100,000 such vehicles. The automobile is much the same vehicle today in size and speed; the change has come mainly from the mere increase in numbers to more than 20,000,000 vehicles in this Country. For various reasons the number of airplanes may not be expected to increase with the rapidity of the automobile, yet it is fair to assume that, with the perfection and advance of the airplane and its natural and steady increase in numbers, the problems of both airports and airways will be radically changed, especially the needs as to location, number and layout of airports and their relation to city and regional plans. No one knows how many airplanes there are in the United States today. The number must be relatively small, but 80 firms are now engaged in their manufacture, and the output during 1927 is said to be 1500 airplanes or more. How many will there probably be 5 or 10 years from now? The answer has a direct relation to the selection, size and character of airports and their relation to city and regional planning. No error is more likely, and none is graver in consequences, than an inadequate estimate of the future.

Another item that a review of city planning may suggest is that of nuisances and amenities. The history of the railroad and the highway has much to teach. Noise, unsightliness and outdoor advertising may be mentioned as illustrations. Aviation offers new and sensational

[1] City and regional planning; past president, National Conference on City Planning, Cambridge, Mass.

means of publicity and potential pleasure. A leading statistical organization recently stated that every roof available for advertising, located on an established air route, will be valuable some day; that such space can be obtained at low prices now and advertisers should sign up the best of these locations for as long a period as possible; that as the airplane industry develops it will bring as many new opportunities as the automobile has brought; and that eventually it will affect real estate values, develop new lines of business and change the travel habits of a large number of people. Unless regulated, this sort of publicity may be a new form of nuisance, like the billboards on our highways.

Cultivating Beautiful Air Views

In contrast to this is the action of some European architects, who have proposed attractive airports as resorts and centers of interest, some of which have already been established, and have demanded artistic views from airplanes. Trips for architects over the larger European cities have been arranged with a view to recommendations for improving the appearance of the city and region from the air. Air touring will become more and more popular. The air sight-seer obtains quickly and agreeably information on topography, architecture, industry and customs of an entire region. The airplane will bring new convenience to resort sections of the Country and widen the whole field of recreation.

Every new form of transportation has some distinctive virtue. To provide for its full utilization is the part of wisdom and common sense. At present it appears to be the peculiar virtue of the airplane to provide travel with new standards of speed for mail, express, news and passengers, for which the world is very eager, and to provide transportation over courses and to places heretofore difficult to reach. An example of the latter is the airplane landing-field to be constructed at an elevation of 4000 ft. on the eastern slope of Mount Hood, Oregon's great ice-capped mountain. We realize more and more that the automobile has by no means come into its own yet, largely because of the "horse and buggy" type of cities remaining as the heritage of the "horse and buggy" type of mind. Have we the initiative, enterprise, skill and business sense to replan our cities to provide properly for aviation? If so, we must begin promptly the planning necessary for a first-class system of airports and airways, and convert the public mind, the public treasury, and the private investor to the supreme importance of aviation in modern life.

Location of Airports

Should airways determine the location of airports, or vice versa? Each, of course, in a careful planning program, will influence the other. But mainly, it seems, airports will determine the location of airways, especially as the development of the airplane comes at a time when the principal cities are well established. While many new towns and cities will undoubtedly be laid out in the future, some of them more or less directly the result of air navigation, the general form of the network of cities may be considered as established. The main reason, however, is that airways and air routes of travel are not much influenced by the kind of considerations that affect the location of railroad right-of-way or of highways. The location of railroads and highways, especially railroads, is determined by considerations such as grade, character of soil, and general topography. Therefore the location and development of a railroad terminal and its importance in a system is dependent to a great degree upon its strategic location.

It seems that air navigation has a much closer analogy to water navigation. The airway system is determined very largely by the selection of airports, just as water navigation is determined by the location of harbors. As with water travel, so with the air, however; the connections and water channels have an important bearing on the port terminals and harbors, and the location, construction, lighting and maintenance of the airways will have a direct influence upon the location and character of airports.

Airports Are a Prime Necessity

The location of airports is the most important and urgent part of the subject of this paper. There are, I understand, already more than 4000 airports and landing-fields of some sort in the United States, owned by States, cities, corporations, clubs, commissions and individuals and the interest in establishing new airports and landing-fields is intense and widespread. They are a prime necessity, as essential as railroad stations, harbors or motorcoach terminals; more so, in fact. Colonel Lindbergh, in his book, We, says:

> Large and well-equipped airports situated close to cities will go far toward developing commercial airlines and keeping the United States at the top in aeronautical activity. . . . The cities that foresee the future of air transportation and provide suitable airports will find themselves the centers of air lines radiating in every direction.

The Airway Bulletin of the Aeronautics Branch of the Department of Commerce gives over 250 examples of municipal airports, with full data as to their location, character and layout. A great and rapid increase in landing facilities is both inevitable and desirable. Air passenger service depends upon a rapid increase of Class A airports.

An airport has been defined as an area either of water or land which is adapted to the landing and taking-off of aircraft, and which provides facilities for shelter, supply and repair of aircraft, or a place used regularly for receiving or discharging passengers or cargoes by air.

There are two major points in the location of airports or landing-fields to consider. The first is the selection of the cities, towns, or places in the open country that will be directly on the air routes and form an integral part of the airport and airway systems. Ultimately, it may be assumed, every place of importance will be included, even though not all may be part of the general airway service. As with other forms of transportation, there will be not only main lines but also branch lines, "feeders," junctions and transfer points. But in these early days, cities and towns that have strategic situations on main routes of air travel, coastal or transcontinental, should be given early consideration as being of first importance.

The second and more important point is the selection of the actual site or sites in a given city or town to be acquired for development as airports or landing-fields. The requirements of all aircraft—airplanes, airships, balloons and seaplanes—should be considered. The choice of the site would, of course, be dependent upon the technical aircraft specifications for airports, and also upon the requirements from a city-planning and regional point of view.

It usually will be found necessary, and perhaps better, for a full-sized airport to be placed on the outskirts of

a city, except where land can be made by filling, as is being done at Lindbergh Field, San Diego, Cal., as shown in Fig. 1. If a number of sites are to be selected, the question arises, Should separate fields be made for different classes of aircraft, or should fields in various locations be used in common for all aircraft? If it is expected that there will be two, three or more ports or fields, the location and also the size may be different than for a single port.

One of the most important questions is, In what sort of a use-zone should an airport be placed, industrial, business or residential; and with what class of property or land uses can it best be harmonized? Local conditions will vary, but it seems that an airport usually can best be classed with industrial property, unless it is possible to place it in conjunction with large public parks, reservations or other open spaces, or semi-public areas like golf and country clubs. Airports are so distinctive in character that it may be desirable to provide for the approval of their location by the board of appeals of local zoning commissions. In this way they often could be placed properly in residential neighborhoods. The zoning of adjacent property, particularly the height of buildings, must also have consideration and control. The approved safe gliding-angle is 7 to 1, therefore a building 50 ft. high makes unavailable any part of a field within 350 ft.

One of the greatest hazards in flying is fog. Therefore no field which lies in a section affected by fog should be chosen if any other is available. Marshes or other objectionable environs of otherwise desirable fields must be carefully considered. The advantage of using a stream or other water area for seaplanes will sometimes outweigh the disadvantage of taking-off airplanes over the water. Airports located at greater altitudes must be larger than those at sea level, as the rare air does not permit the same acceleration. The direction of the prevailing winds is a factor of major importance in the selection and layout of airports.

A level plot with an unobstructed approach in all directions and with a natural turf of such firm texture in all seasons as would eliminate the necessity for prepared runways is the preferred type for an airport. However, such a plot is not always available. The type of soil should be given careful attention. The ground should be firm under all weather conditions. A light, coarse soil with natural drainage is recommended as the most suitable. A field with clay soil demands special drainage and is unsatisfactory, as a rule, during wet weather. As flying-fields should, if possible, be level within 2 deg., adequate and quick drainage is often more of a problem than is anticipated. In many cases it may be more economical to construct runways than to provide an elaborate system for draining the entire area of a large airport without runways.

An airport receiving an "A" rating on its size must

FIG. 1—LINDBERGH FIELD, SAN DIEGO, CAL.

This Field, Which Is Under Construction, Will Comprise 105 Acres of City-Owned Property and 182 Acres of Government-Owned Land, All To Be Reclaimed in Connection with Dredging the Har bor. Including the Marine Base, There Will Be a Runway 2½ Miles Long. The Plans of This Port Were the First To Be Given an AAA Rating

have 2500 ft. of landing distance in any direction with clear approaches and be in good condition for landing at all times, or it must have approved-type landing-strips, permitting landing in at least eight directions. A square field will meet these conditions most naturally. A field receiving a "B" rating on its size must have 2000 ft. of landing distance in any direction with clear approaches and good conditions for landing at all times, or a square landing area 2500 ft. on a side, laid out in landing strips permitting at least four-way landing and having clear approaches. A field receiving a "C" rating on size must have 1500 ft. of landing distance in any direction with clear approaches and be in good condition for landing at all times, or a square landing area of 2000 ft. on a side, laid out in landing strips permitting at least four-way landing with clear approaches. There are also less stringent "D," "E," "F" and "X" ratings on size.

Whatever the size and rating of the original field, and this recommendation needs emphasis, it is desirable that the location should permit easy expansion with increasing need. Changes in the airplane may make a reduction in the size of landing-fields possible. Should the size of airport space be reduced accordingly? Probably not, because the additional space will be required for the increase in the size and number of airplanes and in the use of the landing-field.

Satisfactory landing-fields may have various shapes; they may be square, circular, rectangular, L-shaped, triangular, T-shaped or irregular. The diagrams in Fig. 2 suggest how various shapes of fields may be utilized effectively.

The airport should be bounded on one side, at least, by a public highway of importance, or by a good road making quick connection to such a public highway. Preferably, the field should be surrounded by public streets or highways or by other public property. Ownership of surrounding property is desirable, to establish better control of the field itself and of its surroundings. All wires should be placed underground.

Ground Transportation Connections

It is essential that a site be selected that has good main-highway connections to the center of the city, and, if possible, direct railroad, trolley and motorcoach services. Some good public transportation service is indispensable. To be really effective in large cities, the airplane calls for improved motor roads of the superhighway type established in Detroit. One result of aviation should be better facilities for the automobile and motorcoach, for only in this way can the airplane reach its highest efficiency. Speed from the point of departure to the point of final destination is the test of service. The standard of speed and coordination of traffic facilities cannot be too high. Public utilities, such as electric light, power and water supply, are essential at the field.

Questions of Cost and Ownership

It will be good policy, for both public and private business, to establish early a high standard for airports and a willingness to raise and expend money necessary for first-class service. The cost estimates for airports are at present only approximate, because of the small amount of data available and the naturally diverging standards of early construction and equipment. Land values vary greatly in different parts of the Country and according to proximity to the city. The records show costs of airports from less than $10,000 up to more than $1,000,000. Data secured on 68 landing-fields of various sizes, located along contract air-mail routes, indicate an aggregate investment by the cities of over $17,000,000, with an average cost of $210,415 for fields and $46,912 for improvements.

How should airports be financed, and by whom owned? This question involves the extent, character and rapidity of the future growth of aviation. American public opinion seems to favor the private promotion of aeronautics, combined with the public ownership, maintenance and regulation of both airports and airways. Cities should have adequate power to acquire and condemn land for airports, without as well as within their boundaries, and to raise funds for airports. The public should be generous in its support of aviation, for it has much to gain from aviation. Municipal airports would not preclude additional privately owned landing-fields.

Accessory Features

A landing-field must have not only the essential requirements such as hangars, shops, field stations, customs and storage, rest rooms, restaurants, sleeping quarters, and the like, all well planned and suitably constructed, but also many accessory features such as incidental buildings and adjacent open space for parking automobiles. A liberal margin of land should be obtained also for future expansion of such facilities. There are many examples already of airports of inadequate size, Croydon Field, in London, for one.

Seaplane Port To Be Considered

In many places it will be practicable and advantageous to have the airport located where service can be rendered to both airplanes and seaplanes, combining in the port both land and water areas. The Oakland Municipal Airport, shown in Fig. 3, is a good example of this. At any rate, in making comprehensive plans for cities or towns with important water frontages, it will be necessary to consider the seaplane port. This should be situated on or directly connected with a body of water calm enough for operations in ordinary weather and sufficiently large and deep to permit the landing and taking-off of seaplanes and flying-boats without hazard. By direct connection is meant a canal or other stream of water wide enough to allow taxiing of planes without difficulty, with not over ⅛ mile from the actual port to the open water. Such provision is shown in Fig. 4. The seaplane port or anchorage should be situated on or very near to a good highway leading to the nearest city or town. Besides the basic requirements, which are in general similar to those of airplane ports, seaplane ports receive an "A" rating on size when they have clear approaches and are large enough to permit a 3000-ft. run in any direction. There are also "B," "C," and "D" ratings for seaplane ports as to size, the "D" rating requiring clear approaches and an area large enough to permit a 1700-ft. run in any direction.

Each of the requirements mentioned above must be considered in connection with the others, as with similar features of municipal equipment. In the selection of airports, only special training and familiarity with aviation, and with city and regional planning and administration and related subjects, can be expected to give the best results. The selection and layout of airports are always individual problems. There are general principles, but it requires technical knowledge and special experience to apply them.

After all, airports and landing-fields are merely terminals or stations or transfer points in a system. Therefore, consideration must be given to airways and the relation of the airports and landing-fields of a series to one another, and to the services essential for aircraft along the lines of airways. This requires regional planning, or rather, National planning, as the airplane makes the Nation a unit and calls for a consideration of the same principles as the regional planning of railroads, highways and waterways.

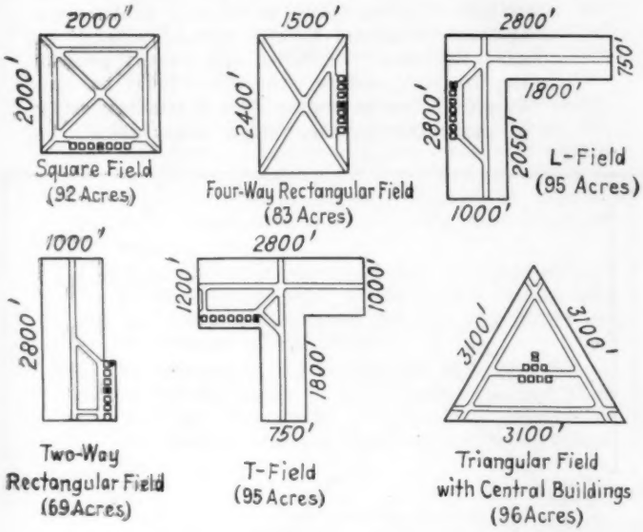


FIG. 2—TYPES OF LANDING-FIELD

Runways Can Be Arranged According to the Land Available. A Surface Suitable for Landing or Taking Off in Any Direction Is Better than Runways

The term "civil airway" is considered to mean a route in the navigable air designated by the Secretary of Commerce as suitable for interstate or foreign air commerce. In the location of airways the existing network of cities and towns must be considered, which means, usually, following in general the existing railroads and main highways. The airway system, however, permits much greater freedom and differentiation because of its character. Again, it may be pointed out that air navigation has the elastic element and the simplicity that characterize water travel, as compared with land travel. Without prohibitive cost or difficulty, direct routes between large and important places may be established.

However, as in the case of water travel there are many limitations, as the depth of channel, and requirements such as lighthouses, lightships and buoys; so, with air travel, the airways have obstructions to avoid and call for an elaborate system of intermediate landing-fields, lighting, radio beacons and radio telephone service, dissemination of weather information and forecasts, and the like. The economical use of the airplane and the requirements of speed demand flying by night as well as by day and in all vicissitudes of weather and season. The present program of the Department of Commerce calls for the lighting of over 6000 miles of airways, and the Post Office Department now lights more than 2000 miles. The cost of lighting an airway is so great that the permanency of any proposed route must be carefully considered. An adequate system of intermediate landing-fields is imperative.

Many cities and towns will be considered for related air service that cannot be reached easily from each other by railroads, highways or waterways. Such service will be very important over mountain ridges or marshes, along water courses not navigable, and between places where the direct route is over both land and water.

COORDINATION OF TRANSPORTATION

Air systems need not follow very closely other systems of communication but they must be coordinated with other city and regional transportation systems for unity. Important errors of the past have been the failure to link up conveniently and economically land and water transportation and the lack of coordination of various forms of land transportation. How can the infant air

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FIG. 3—THE MUNICIPAL AIRPORT AT OAKLAND, CAL.

With an Area of 825 Acres, and a Runway Over 7000 Ft. Long in the Direction of the Prevailing Wind, This Port Has Ample Space. It Is Located on a Peninsula Between San Francisco Bay and San Leandro Bay. Contestants in the Dole Flight Took Off from This Field

service be coordinated with existing systems of transportation?

Planning for railroad, highway and water transportation has not been comprehensive and farsighted enough in anticipating the changes and expansion. To plan successfully, some prediction of the future is necessary, although prediction in engineering matters, particularly in airplane matters, is always dangerous because at any moment the course of normal progress may be revolutionized by some outstanding discovery or invention. A large part of city and regional planning is an attempt to forecast the future. Is there not room for a discovery of the future and more definite planning for it in connection with aviation?

In conclusion, the following points deserve emphasis:

(1) Every city or town of any importance should have an airport and supplementary landing-fields as service stations, generally publicly owned. The standard as to size, convenience and safety should be the highest possible in each instance. Facilities often must precede the demand, and services often must be conducted at first at a loss. This is true especially of passenger service. Such losses should be

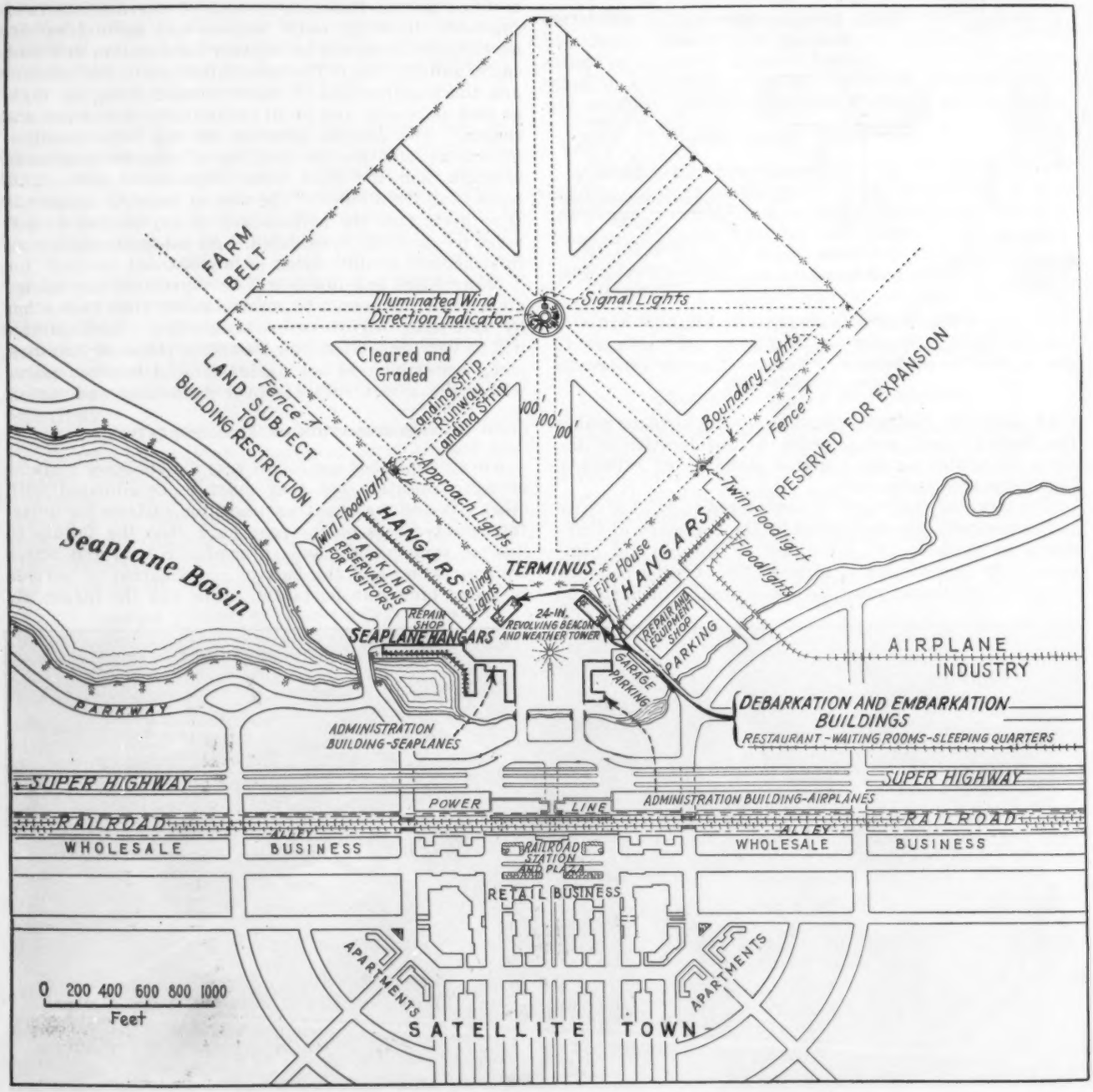

FIG. 4—PLAN OF HYPOTHETICAL AAA AIRPORT WITH SEAPLANE BASIN

This Plan Has Been Prepared by Mr. Nolen To Illustrate One Method of Carrying Out the Government Specifications According to the Highest Standard. The Equipment Shown Includes Hangars, Waiting-Rooms, Sleeping Quarters, Repair-Shops, Restaurant, Weather Tower, and Fire-Fighting and First-Aid Equipment. Adjoining the Location Are a Super-Highway, a Railroad Line and a Satellite Town. To Receive AAA Rating, a Field Must Have Runways 2500 Ft. Long

borne by the public, because the advantages are for the public.

(2) The experience of various authorities in selecting, planning, developing and maintaining airports and airways should be assembled constantly and made public. The Aeronautic Branch, Department of Commerce, issues illustrated air-bulletins describing airports and improved intermediate fields, and there are other sources, both public and private, of reliable information.

(3) The site for an airport should be chosen early, with the highest possible standard from the viewpoint of the aviator, and with due regard to the requirements of city planning and zoning. Permanent airports should be selected with great care and with the best technical advice.

(4) One of the chief merits of any proposed airport is the facility with which it can be changed and expanded to meet the new and larger requirements of the future.

(5) The principles determining the right location of railroads, highways and waterways and their stations, terminals and harbors should be recognized, and the experience of comprehensive city and regional planning and zoning should be secured by those responsible for the planning for aircraft service.

(6) Aviation authorities should have the cooperation of local and regional planning boards, and of the National Conference on City Planning and the American City Planning Institute. These National organizations, so far as their resources permit, can aid in various ways in the research and discussion necessary for a wise solution of the broad planning and zoning problems related to aviation. In return, aviation is making valuable contributions to city and regional planning by airplane surveys and in the facilities it affords for the study and observation of cities and regions from the air.

Tribute should be paid to all those agencies, both public and private, that are working so effectively and whole-heartedly to advance aviation, especially to the aeronautics branch of the Department of Commerce. Advance in the solution of problems of establishing civil and commercial airway systems, with adequate and appropriate airports and landing-fields, will depend to a great extent upon the action of this department, working in cooperation with State and local authorities.

THE DISCUSSION

DAVID DARRIN[2]:—Every point in connection with airport location, design and equipment should be reviewed finally from the cockpit of an airplane, through the pilot's eyes. Each point should require the pilot's consent and approval before it is decided upon, to the end that every detail of location, arrangement, equipment and operation may combine to produce the maximum safety under the most unfavorable flight conditions.

H. H. THOMPSON[3]:—I believe it is most logical to locate the airport near the main line of a railroad rather than on an improved highway. Locating airports in such a manner may be inconvenient for the present, but in the future such locations will be of inestimable value. The airplane wins its place in the transportation field by virtue of its speed. In view of the congestion of our cities, the maximum speed of transportation from the airport to the heart of the city can be obtained only by rail. Congestion of traffic on the various highways entering a city will be such that transportation by motorcoach or trolley from the airport to the city will greatly reduce the advantage of air transportation. Traffic over the main line of a railroad can be controlled so that the right-of-way will be given to all trains from the airport to the city. In fact, when such transportation becomes fully developed, a special track can be laid which will not be interfered with by other lines.

It is not improbable that, in the future, all passengers and express between cities will be carried by airplanes, and all freight by the railroads. If this is true, it is necessary to locate the airport at such a point that expansion of the port can be made with the minimum of cost. Large tracts should be acquired by every large city to permit expansion as the industry grows. In planning an airport, the requirements for the next 50 years should be considered. The airplane of the future will be larger than the airplane of today, as the number of cars handled today by a locomotive is larger than the number handled by a locomotive 50 years ago.

As the industry develops, manufacturers of airplanes will locate assembly plants at the airports of the various cities. Here they will be able to test each completed plane prior to delivery. Every large city should consider at least two airports, one for the terminal of air-transport lines and the other for privately owned pleasure and business planes. In each case, the railroad should be considered as the most logical and quickest means of reaching the heart of the city.

POSSIBILITY OF ROOF LANDING-FIELDS

WARREN H. MANNING[4]:—More attention should be given to the possibility of roof landing-fields in a city. I believe it to be practicable to provide large landing-fields on the roofs in portions of a city where the height of the structures is uniform. The trend toward one-story factory structures may mean very large areas devoted to this type of building.

Study should be given also to the recreational values of the airplane and to the importance of acquiring landing-fields near the centers of great recreational regions throughout America, represented by the Allegheny, Catskill and Green Mountains. To such centers commuters may come quickly in airplanes from the big cities. Their cars will be cared for during the day at these centers.

STATE BOUNDARIES NOT AN INSURMOUNTABLE OBSTACLE

FRANK B. WILLIAMS[5]:—A city probably has the power to acquire airports that are within its own limits. Whether it can acquire an airport outside of its own boundaries is a more doubtful question. In many cases cities have the power to acquire parks outside their boundaries, either by purchase or by condemnation. Whether they can so acquire airports depends on whether the legislatures, in the patchwork which they have created for the government of many of our cities, have happened to use language that is broad enough to

[2] Construction engineer, Thompson-Starrett Co., New York City.
[3] General engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
[4] Landscape design and regional planning, Cambridge, Mass.
[5] Legal adviser, Regional Plan of New York City and Its Environs, New York City.

include airports or whether someone has been intelligent enough to give that specific power.

Probably a city could not acquire land for an airport outside of the State in which it is located without legislation by both States concerned, but there has been such legislation for acquiring watersheds, allowing condemnation of the land needed. So State boundaries are not an insurmountable obstacle to the proper location of an airport.

In case a landing-field is wanted at the edge of the water, to accommodate hydroplanes, it is important to know the facts with regard to the title to the land below high-water mark. If the State has not granted away the title it can often transfer the land to the city as a part of the field, free of charge, provided no injury would be caused to navigation and any damages were paid to the owner of the upland. But in a case like this it is probable that there would be a gain to navigation and that the upland owner would be benefited rather than injured. Often an area such as this can be obtained and developed at a relatively small expense.

Proper location of other industries and activities with relation to the airport should be regulated in an orderly way by zoning laws and zoning commissions. High buildings that would shut in the field must be guarded against. In most States there are laws that enable cities to pass zoning ordinances. It is to our interest that cities should avail themselves of those laws and should put on such commissions men who are technically cognizant of aeronautics.

Modern Road Surfaces

THE surface of any highway constitutes the ultimate end of the engineer's labors. The perfect road surface of today should possess, among others, the following characteristics: long life, low maintenance cost, low initial cost, good surface texture, homogeneity, freedom from distortion, and low ultimate cost.

Road surfaces are being called upon to sustain a daily traffic intensity ranging up to a maximum of 31,000 tons per day, and many instances occur to prove that the volume has increased threefold at certain points within 3 years. These figures apply to conditions outside the metropolitan area of London, within which still higher values are obtained, and the intensity of loading, assuming uniform distribution across the width of the highway, reaches such exceptionally high figures that already many road-making materials are being stressed very highly indeed.

The ultimate financial test must be based upon the cost of construction and maintenance per year divided by the tonnage carried by the road; that is, the ton unit-cost. The mechanical problem in actual construction is no less tantalizing and intricate.

Causes of Surface Corrugation

A review of the road today would fail of its purpose if it contained no reference to certain minor defects which exist, and which, so far, have not been entirely eliminated. Of these, the most scientifically interesting is corrugation, or wave formation. Commonly, this is more pronounced and emphatic in the more plastic materials, and certain clear evidence of flow is discernible. It is impossible to dogmatize, for deformation amounting to corrugation is also observable in the rigid materials, such as concrete and wood-block paving. An easy and convenient theory is that corrugation is caused by steam rolling. This is too obvious and ready an answer and is only partly true, insofar as it initiates the minor deformations at the preliminary stage. The real explanation, it would appear, lies in stresses set up by fluctuations in impact, or loading, due to the springing of vehicles, and that there lies a definite ratio between the periodicity of a vehicle spring, speed and wave frequency. This can be more closely realized if, when examining the case of wave formation where a certain type of traffic predominates, that is, a regular motorcoach service at close intervals, it is noted that the loading imposed upon the road is not constant or static in value, but is constantly variable and ranges from a negative to a high positive value.

A road surface, of whatever type of construction, has a coefficient of friction with a value constant to that surface, but which varies in amount between surface and surface, and has a separate value for varying atmospheric conditions, that is, dusty, clean, moist, wet, or, more simply, whether dry or lubricated. The value of such coefficient has a meaning in securing the necessary adhesion between the wheel and the road, to develop the full propulsion effort of the prime-mover, and so prevent wheel-spin, especially when accelerating, and, lastly, to secure safe and rapid retardation. There is, at times, much loose criticism of road surfaces in relation to this question, and, since a scapegoat is necessary, the road, no doubt, serves as well as another, since it is impersonal. This criticism is all directed to the fact that skidding, or, more truly, sliding, takes place under certain well-known and obvious conditions. Surely, in so important a matter as this, the sole question is one of fact. So far, absolute records do not seem to be available, and the accompanying table is, therefore, put forward as an indication of the values which may ultimately be assigned to principal groups or types of surface.

COEFFICIENTS OF FRICTION OF RUBBER ON MAIN GROUPS OF DRY ROAD-SURFACING MATERIALS

Material of Surface	Coefficient of Friction
Rubber	0.693
Tar-Treated Surface, Including Sprayed, Grouted and Tar-Macadam	0.494
Bitumen, Including All Types of Asphalt or Bitumen-Treated Surface	0.597
Wood-Block Paving	0.590
Concrete	0.486

Tire Problems

In relation to road surfaces, the contact of the vehicle is secured by its tires, and it is precisely at this point that the modern pneumatic tire, excellent as it undoubtedly is under modern scientific control and improved manufacturing processes, falls short of perfection. The tire which, when new and with the pattern of tread chosen by the maker, will give excellent adhesion and security under dry-weather conditions on most types of road surface shows a marked falling-off when the road is partly or wholly wet.

The introduction of the balloon, or low-pressure, tire has not been lost sight of, but the enormous increase in the number of new vehicles per year, the increase in speed, in new drivers and, therefore, lack of skill, and, to sum up, the all-round increase in danger, justifies a most searching review of the position and a frank attempt to aid in solving one of the most difficult road problems with which we are faced.—R. G. H. Clements in *Modern Transport* (London).

Modern Lacquers and Their Use

By Dr. G. C. Given[1]

Annual Meeting Paper — *Illustrated with* Charts

DISCOVERY of a method of producing cellulose-nitrate lacquers in a highly concentrated form of low viscosity without impairing their film strength makes possible the giving of as much protection with one coat of this present automobile finishing material as with three or four coats of the earlier lacquers, according to the author, who asserts that a film thickness of only 0.0015 in. suffices to give complete protection.

Durability of the finish, which is the first consideration, is influenced markedly by proportions of the pyroxylin, or cellulose-nitrate, to other clear ingredients, by the ratio of pigments to non-pigment solids, and by the kinds of pigment used. Long-time outdoor exposure of the lacquer finish seems to be the only sure method of testing for durability.

A low ratio of pigment gives a high gloss but reduces the durability. The only safe method to produce gloss is to control the manufacture of pigments and grind them thoroughly into the carrier, as coarse unevenly sized particles will result in a flat finish that cannot even be polished to a high gloss. Gradual but marked increase in gloss has been made in the last 3 years.

Working properties of lacquers, which are to the finishing engineer of secondary importance only to their durability, are listed under nine items and discussed individually. Although two good average spray-coats will give sufficient thickness for protection, four or five coats of light cream colors seem to be needed to hide the undercoats completely. The use of undercoats differing in color from the final finish is desirable to warn against thin spots in the covering coats.

High-grade lacquers are now being applied with only 3-min. drying intervals between coats and with a final drying for 15 min. before sanding. Increase in the proportion of thinner results in greater smoothness but necessitates more spray-coats; hence it is more economical to spray with less thinner and apply fewer coats.

Mist-coating with a very wet coat of thinner containing a large proportion of active, slow solvent is recommended after the sanding operation as a means of eliminating all sand scratches.

Power rubbing and polishing machines have not been found satisfactory by the author, but he believes they will be perfected and fill a great need. Buffing, after polishing, with a soft cotton buffing-wheel on a flexible shaft and without using buffing compounds, results in considerable improvement in the final finish.

Adequate ventilation and daily cleaning of the spray booths and room are necessary safety precautions against fire hazard.

The discussion deals in the main with the danger of explosion, the gums and solvents employed, the correlation of results of indoor and outdoor exposure to actinic rays, the prevention of damage to the finish by alcohol, and the development of pyroxylin primers to replace high-baked or long-air-dried primers.

ADAPTATION of cellulose-nitrate, or pyroxylin, lacquers to automobile finishing was brought about by the discovery of a method of producing these products in a highly concentrated form of low viscosity without impairing the film strength. This discovery made possible the manufacture of a lacquer of sufficiently high pyroxylin content to give durability without excessive cost. The older lacquers, because of their low concentration, required three or four coats to give as much protection as one coat of the present material.

The modern lacquer consists of a solution of pyroxylin, plasticizer and resin, or gum, into which a suitable pigment or combination of pigments has been ground. The material used to dissolve these ingredients is a mixture of solvent and non-solvent, or diluent, in proper ratio.

When a lacquer dries, the solvents and non-solvents evaporate, leaving a film consisting of the solid ingredients. In the older oil-type paint and varnish finishes the oil takes up oxygen slowly from the air and is thereby changed from a liquid to a solid. Therefore it is said that a lacquer dries by evaporation and a paint by oxidation.

To be considered durable, a finish should not change color, crack or craze, check (take on the appearance of of alligator skin), peel, nor scratch readily, and it should protect the underlying surface from the action of the elements.

These qualities of durability are all influenced by the composition of the lacquer. Too low a ratio of pyroxylin to other clear ingredients will produce a finish that will either craze or check. Too high a ratio will impair the adhesion. The pigment used in a lacquer also has a great influence on the durability. Even with properly balanced clear ingredients, if the pigment be of the incorrect type the finish will fail in a very short time. A notable example of this type of failure occurs in the case of some of the deep wine-colored maroons. Some pigments used to obtain this shade are not suited for lacquer manufacture, even though they may have been suitable for the older oleo-resinous finishes.

The proportion of pigment as compared with the non-pigment solids also has a marked effect on the durability. If the content of pigment be too low, failure will occur very promptly by checking; if it be too high, cracking is likely to result and, if this does not happen, the chalking will be excessive.

There seems to be no generalization that can be depended upon regarding the action of pigments in favoring or impairing durability. Actual long-time outdoor

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exposure of the finished lacquer seems to be the only sure method of testing for this quality. It is advisable, also, to choose well the place for the exposure. A demonstration of the great difference between Florida and New Jersey in the time required to produce failure is snown in Fig. 1 Panels of a short-lived maroon finish were prepared and placed on exposure boards in the two locations at weekly intervals. The number of weeks before failure occurred is shown by the curves. For example, a panel exposed in Parlin, N. J., on Dec. 1 failed in 32 weeks, while one exposed on Aug. 1 failed in only 4 weeks. The same short-lived lacquer failed in 12 weeks after exposure in December and in 4 weeks in June in Gainesville, Fla.

Since gloss is a desirable feature in a lacquer finish and a high gloss can be produced by using a low ratio of pigment, there has been a great temptation to pro-

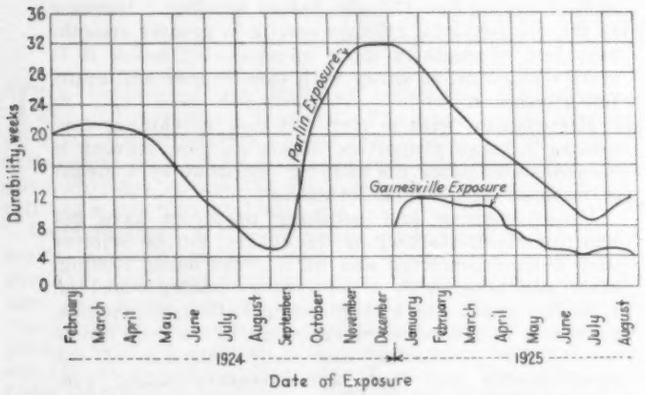

FIG. 1—EFFECT OF SEASONAL EXPOSURE ON DURABILITY OF LACQUER FINISH

Panels Were Exposed Monthly at Parlin, N. J., and Gainesville, Fla. The Upper Curve Shows Greater Durability of the Finish in New Jersey than the Lower Curve Shows in Florida. Durability of a Short-Lived Lacquer in December, under Northern Winter Conditions, Was Eight Times as Great as in August under Summer Conditions. In Florida the Same Lacquer Failed in 12 Weeks after Exposure in December and in 4 Weeks in June

duce the high sheen so desired by the lacquer user by following the line of least resistance, that is, by cutting down the pigment-ratio so much that durability is impaired. The only safe method, at present, to produce gloss is by careful control in the manufacture of pigments and by the subsequent thorough and complete grinding of the pigment into a proper vehicle. A lacquer made with pigments containing coarse, unevenly sized particles will not only be flat but cannot even be polished to a high gloss. The gloss of durable lacquers is higher than in the past. The increase in gloss has been gradual, but if a comparison were made between lacquers of 3 years ago and the present ones, the improvement would be seen to be very great.

WORKING PROPERTIES OF CHIEF INTEREST

Second only to durability, the finishing engineer is interested chiefly in the following properties of a lacquer:

(1) Number of coats required
(2) Time of drying between coats
(3) Smoothness of final finish, or "orange peel"
(4) Ease of sanding
(5) Ease of polishing
(6) "Pull-outs"
(7) Ease of repairing, or "touch-up"
(8) Bridging
(9) Masking

NUMBER OF COATS VARIES WITH CONDITIONS

The number of lacquer coats will vary over rather wide limits because of different conditions of air-pressure, different spray-guns used, different degrees of hiding power, and the like. It has been discovered, however, that a durable lacquer film from 0.0008 to 0.0015 in. thick is sufficient for complete protection. But frequently it is necessary to put on a greater thickness because of the low hiding-powers of the lighter colors. Two good average spray-coats will give a film thickness of 0.0008 in. but only a dark-colored lacquer of this thickness will be sufficient to hide the undercoats completely. Four or five coats of some of the light cream colors seem to be necessary.

As it has been carefully determined that a thickness of 0.0008 to 0.0015 in., depending on the color, is required to give the necessary durability, care should be taken that at least this much be left on the work. Colored undercoats of poor durability have sometimes been used in attempts to save lacquer. These undercoats are frequently of so nearly the same shade as the final finish that thin spots remain undiscovered and failures occur at these places. If the somewhat questionable general use of ground-coats is to be continued, it is desirable, for this reason, to have them differ considerably in color from the final finish.

The thickness of coating that can be applied with one spray-coat is dependent on the concentration of the lacquer at spraying viscosity. This, in turn, depends on the character of the pyroxylin. There seems to be no present prospect of increasing the concentration of the lacquers as sprayed, if the present standards of durability are to be maintained. If the viscosity-concentration relationship be much lower than that now used, the lacquer loses many of its desirable qualities.

DRYING TIME, SMOOTHNESS AND POLISH

High-grade lacquer finishes are being applied at present with only 3-min. drying between coats at 125 deg. fahr. After the last coat is applied it is advisable to dry for about 15 min. at the same temperature before the sanding operation. Adequate ventilation is necessary in the drying chamber, as lacquers dry by evaporation. This schedule is about all that could be desired.

The smaller the proportion is of thinner added to a lacquer for spraying, the more is the "orange-peel." Conversely, increase of thinner reduces the "orange-peel." It might seem, therefore, that there is no reason for not being able to produce a smooth finish simply by increasing the proportion of thinner. The difficulty is that when more thinner is added more spray-coats of lacquer are required to produce the desired finish. It is found to be more economical to spray with less thinner, applying fewer coats, and then to sand-out the "orange-peel" with sandpaper and oil or other sanding liquid.

Ease of polishing is related intimately with control in the manufacture of the pigments and of the lacquer itself. Variations in the size of pigment particles, or lack of thoroughness in the grinding of the pigment aggregates, will produce microscopic irregularities in the film which will break up the light and give a hazy or flat finish.

"Pull-outs" frequently are encountered on the polishing deck. These are small comet-shaped blemishes caused by the pulling out of particles of some foreign substance from the film by the polishing rod. A lacquer should be kept free from foreign material such as cin-

ders, dirt, and lint. The trouble may come also from unclean conditions in proximity to the spray hoods.

Few automobile bodies pass the inspectors without having to be patched. There will be places where the finish has been rubbed too thin or even rubbed through; or the finish may have been bumped while wet. These marred places must be patched with the same lacquer as was used originally, and the finisher is interested in leaving no evidence that a patch has been applied. Very close control of formulation is required to assure the absence of trouble in patching. Because of the differences in density possessed by the various pigments, and because of the difference in the drying time between the main part of the body and of the patch, a slight "floating" of the pigment frequently occurs which causes an off-colored ring to appear around the edge of the repaired spot.

Noticeable improvement has been made in the last few months in the facility with which touch-up can be done without trouble. However, there are still some shades which cannot be patched without great difficulty. With some maroons, for example, a touched-up spot is so plainly evident that it is frequently necessary to respray the entire panel. It is hoped that further improvements along this line will be forthcoming.

It is a recognized fact that the finishing cost averages considerably higher with certain colors than with others. However, if there is a public demand for these more expensive shades, bodies undoubtedly will be finished with them. Care should be taken that the finishing engineer does not underestimate his costs when, for example, maroons and light creams are involved.

Advantageous Practices in Finishing

After the "orange-peel" has been removed by the sanding operation, there will always be left the small scratch lines of sandpaper. These can all be removed by sufficient work with rubbing compound, but much of this hard rubbing can be avoided by the use of a "mist-coat." As this is not used in all shops, it is worthy of full discussion because of its advantage.

The mist-coating operation consists in applying a very wet coat of a high-grade thinner containing a large proportion of active, slow solvent to the finish after the sanding operation. Its effect is to dissolve the top layer of dried lacquer and thereby cause it to flow out into the sandpaper scratches, building them up level with the rest of the surface. Since the hood and the body are frequently finished in different shops, it occasionally happens that the mist-coating operation is performed on one and not on the other, and the difference in the finish is marked, even to the inexperienced eye. It is believed that the custom of mist-coating should be adopted universally.

In the past it has been customary, when lower costs were desired, to confine the operation of sanding-out the "orange-peel" to the most conspicuous places. Perhaps half of the cost of sanding may be saved by this practice. Because, however, of the more critical attitude of the public, this custom is almost abandoned. Even if other places are slighted, it is well to sand the cowl and upper portions well.

Many devices operated by electricity and by compressed air have been devised in attempts to produce a machine that will save a large amount of the hand labor expended in the sanding and polishing operations. It is not believed that any automotive production shops are now equipped with such apparatus. Two general types have been offered: (*a*) the rotary type having a rotating member attached to a flexible shaft, and (*b*) a reciprocating type in which the power is applied on the inside of a member that is light enough to hold in the hand.

My experience has been that the rotary type always leaves whorls which are plainly visible and difficult to remove, while those of the reciprocating type, because of their necessary lightness, knock themselves to pieces in a short time. The need of excessive lubrication in the reciprocating type makes them particularly unsuited for sanding surfacer because of the constant spattering of oil on the work. If such machines can be perfected, and they probably will be eventually, they will fill a great need in the finishing shop.

In many custom refinishing shops it is the practice to buff, after polishing, with a clean soft cotton buffing-wheel on a flexible shaft, without using buffing compound. This operation results in a considerable improvement in the final finish. It is mentioned because it is believed that this is not being done in any automotive manufacturing plants.

The masking operation as performed at present is slow and expensive. It is believed that the devoting of considerable time and attention to devising some improved system of masking would be well repaid.

Safety Precautions in Use of Lacquer

Any discussion of lacquers invariably brings up the question of safety precautions and fire hazard. It is generally agreed that the requisites for safe operation are adequate ventilation and good housekeeping.

Rule 6 (b) of the regulations for spray-coating issued by the Michigan Department of Labor and Industry provides that exhaust systems shall be so designed as to maintain an average air-velocity of not less than 90 linear ft. per min. at the face of the booth. This seems satisfactory for the ordinary booth, but it is believed that this rule should be given an interpretation by the committee when the customary staggered spray-booths are used.

Daily cleaning to remove dust is of vital importance. The dust hazard is much more to be feared, it is believed, than the volatile-solvent hazard, as ventilation can be maintained mechanically, whereas good housekeeping requires both labor and supervision.

One vital reason for good housekeeping, other than as a safety precaution, is that it materially lowers costs and improves the general appearance of some finishes by preventing the settling of dust or lint on the wet lacquer. Dust from a bleeding red or maroon, settling on a light color, will produce red spots of such persistence that it is frequently necessary to sand them down to the undercoats to remove them. This sanding-down and refinishing, because of its special nature, probably will cost almost as much as an ordinary job that has passed through the regular line in perfect condition.

Some Shortcomings of Lacquers

No one is of the opinion that lacquer finishes are ideal. Many shortcomings are yet to be overcome. The ideal finish would not, for example, require so much hand labor. There are many problems to be solved with reference to undercoats. A high smooth gloss without polishing would be very desirable. No one realizes the necessity of continuous development better than the lacquer manufacturer himself. Speaking for one manufacturer, it may be said that more men are employed at

present and more money is being spent currently on research problems relative to finishing than at any time in the past. There is no thought of resting on our oars or of letting well enough alone.

THE DISCUSSION

QUESTION:—What is meant by high-power solvent? Does that mean solids?

DR. G. C. GIVEN:—There are no solids in a mist-coat thinner. It is a mixture of solvents containing a large proportion of active pyroxylin salt which is more or less of the slow-drying type.

PRESIDENT J. H. HUNT[2]:—Has anything been done with the lacquers themselves from the fire-risk standpoint? There will always be a risk with the solvent, but are all of these organic dusts of equal danger and is there any prospect of improving the situation?

DR. GIVEN:—An organic dust, when it is oxidized and explodes, releases a certain number of calories of heat and provides a certain volume of exploded gas. A kilogram of cellulose-nitrate gives off 1045 kilogram-calories when it burns. It has not quite enough oxygen to burn itself, but, as a dust in the atmosphere where it has all the oxygen it wants, it will develop 1045 calories and give about 900 liters of gas. Linseed oil, when suspended as a fine mist in the atmosphere and burning with an excess of oxygen, gives out 9000 calories and develops 2700 liters of gas. That means that, pound for pound, a suspended mist of linseed oil would give about eight times as violent an explosion as a pound of cellulose-nitrate. As a matter of fact, cellulose-nitrate would give less than almost any other substance, because the oxygen in it constitutes so large a fraction of its weight.

Many people think of nitroglycerine as a violent explosive. It is, because it carries its own oxygen and, when confined in a tight place, does not need any oxygen from the outside, but the number of calories and the volume of gas that result from its explosion are relatively small. Nitroglycerine has an excess of oxygen and is a relatively heavy element, heavier than carbon. I should say that flour dust, for example, would give probably four times the explosion of cellulose-nitrate. Aluminum powder gives violent explosions because of the enormous heat evolution, and so does coal dust.

ALL SUSPENDED ORGANIC DUSTS EXPLOSIVE

PRESIDENT HUNT:—Are there some materials for lacquers that are not so inclined as some others to let go when they are persuaded?

DR. GIVEN:—Probably almost any organic material that would be used in lacquers, if it could be suspended in the air, would be likely to give a more violent and destructive explosion than cellulose-nitrate.

PRESIDENT HUNT:—How about the probability of having the explosion?

DR. GIVEN:—The probability is a matter of whether the dust is present. I think the solvent part is very readily taken care of, but if a large vapor-proof type of electric light, we will say, has a half-inch of dust on it and somebody hits that so that the dust falls and the globe breaks, you would get an arc or spark of high enough temperature to ignite the dust; then the puff and the flare from that would lift the dust in other parts of the room and you would have a wave of this dust burning.

PRESIDENT HUNT:—Do you think there is no hope of lacquers being better from that standpoint?

DR. GIVEN:—Not so long as organic material is used.

QUESTION:—Can you use inorganic lacquers?

DR. GIVEN:—That might be done; I do not know.

QUESTION:—I understand that certain kinds of gum are used in various percentages to give gloss. How would you attain a high degree of luster, by reducing the pigment? What types of gum are being used mostly now?

DR. GIVEN:—Three general types of gum are being used. They are ester, Dammar and some synthetic gums. If more gum is put into a given lacquer it will give a better luster. If the content of pigment is reduced, a better luster is obtained; and if the gum is increased and the pigment decreased, a still higher luster is produced. However, a delicate balance must be maintained in the lacquer, in my opinion, to keep the durability where it should be. That means a fairly low gum and a rather high pigment content.

INDOOR AND OUTDOOR TESTS CORRELATED

QUESTION:—Has any progress been made in correlating the tests made indoors of the effect of actinic rays with those made by exposure outdoors?

DR. GIVEN:—Yes, for 5 years or so.

QUESTION:—Have you reached any conclusions?

DR. GIVEN:—The conclusion would be that the results of tests of the actinic rays indoors are 80 per cent correct. One never knows which finish is going to be a failure.

QUESTION:—Is anything being done to make a lacquer that will not be damaged by alcohol?

DR. GIVEN:—Yes. The present lacquers are injured to some extent by alcohol, but usually the marks do not remain if the alcohol is rubbed off immediately and the surface is then polished with some of the ordinary polishing compounds on the market.

H. L. SCHROCK[3]:—What advances have been made in the last year in regard to pyroxylin primers to take the place of high-baked or long-air-dried primers?

DR. GIVEN:—Some pyroxylin primers are being used at present. Their use is largely a matter of the conditions in the plant. There is a place for them undoubtedly and, so far as I know, they are satisfactory where they are used.

MR. SCHROCK:—So far as I know, only one concern in the automotive industry is using them on a production basis, and it has been using them for about 2 years. It seems to me that there must be some reason for other manufacturers not using them, for their use would certainly result in a great saving in floor space, heat and equipment.

DR. GIVEN:—I know of no improvements in the quality of pyroxylin primers during the last year, nor do I believe that their use in general production has increased. Their use in "touch-up," however, has increased considerably. Under the assumption that a finish can be obtained with a pyroxylin primer which is just as good as that obtained with a high-bake or long-air-dry primer, I believe it would cost more to use a pyroxylin primer if the manufacturer has adequate floor space and drying ovens. On the other hand, if floor space and drying ovens are inadequate, he is forced to use pyroxylin primer regardless of cost.

[2] M.S.A.E.—Chevrolet Motor Co., Detroit.
[3] Assistant superintendent of paint, Hudson Motor Car Co., Detroit.

Army System of Motor-Transportation Maintenance

Discussion of Lieut. W. C. Thee's Transportation Meeting Paper[1]

A MORE appropriate title for this paper would be The Application of the Laws or Fundamental Principles of Industrial Organization and Management to the Maintenance of Motor Transportation. This title furnishes the explanation how and why the Army maintains its own equipment, operated in all parts of the world, with soldier labor. It also helps to explain how the Army has maintained its own equipment at a cost much lower than have any other operators of motor transportation.

The Army, with its operating centers widely dispersed and its maintenance or repair centers closely combined, is admirably situated to recommend to commercial operators of motor transportation its system of maintenance. The influence that the laws of management have had in the advancement of the maintenance of motor transportation from the vocational to the professional plane may be exemplified by citing a few instances of the direct adaptation of the laws or fundamental principles of management to the Quartermaster Corps Motor Transport, Reconstruction Park, Camp Holabird, Baltimore.

The author discusses the great shortage of skilled mechanics who are required for the maintenance of the ever increasing number of motor-vehicles, and the difficulty of getting satisfactory service. He also explains how the Army is solving the problem of securing a sufficient number of men to do satisfactory work in maintaining the motor-transportation equipment operated by the Army. In accordance with the laws of management, the three accepted ways of getting satisfactory work done by unskilled labor are, division of labor, leadership, and incentive reward. Other accepted ways are, authority with responsibility, transfer of skill, and task work. The Army shops at Camp Holabird apply these laws and fundamental principles by dividing the shops into departments and subdividing the departments. The labor of maintaining and reconditioning motor-transportation equipment is divided so that to each worker is assigned either one or a very few manual or mental operations. This one factor in management tends greatly to improve the quality and to increase the quantity of the output of unskilled labor. The term "skilled labor" or "expert mechanic" is minutely defined by the author.

Another important factor that the shops at Camp Holabird demonstrate in a very clear way is the assigning of a definite task to each department or group of workers by the use of production boards which show the quantity required to be produced in a given period. These departmental production boards not only set a definite task but create incentive in the workers by giving them credit for the work done. When the men are given credit for their work through the posting by its foreman of the number of units completed by each group of workers, they have an incentive to work fast and take an interest in the organization.

Means of increasing production are described and illustrated with charts. The statement is made that during the last year considerable study has been devoted to the subject of the unit-replacement system for making adequate and satisfactory repairs to motor-transport vehicles.

F. K. GLYNN[2]:—Does Lieutenant Thee believe that the present plan of centralized rebuilding of motor-vehicles at Camp Holabird, Md., is more economical than a plan providing for repairs of vehicles at commercial service-stations close by the assigned location of the vehicles?

LIEUT. W. C. THEE:—I think I could prove in many ways that it is more economical, but I have no cost figures with me. But I can say from my experience with the Army motor-service in Boston, that if we had to send fenders, upholstery, engines, axles or other units outside to be repaired it would cost much more to have them repaired at commercial service-stations than to have them repaired at Camp Holabird.

Concerning engine-repair, in one instance a Signal Corps truck engine sent outside for repair could have been repaired for about one-quarter the expense at the Camp. Repainting our Cadillac vehicles with nitrocellulose paint costs from $200 to $300 for a limousine at commercial shops, but the cost is much less at the Camp. Repair work outside is very expensive and we try to anticipate our demands so that we can get extra tops, extra seat covers, extra cushions and various other units from Camp Holabird and keep them in stock so that we do not need to send unserviceable units out locally to be repaired.

Under the unit-replacement system that we use in the field, if an engine becomes unserviceable and we have not the mechanics or the facilities to make those repairs, say in Boston, the old unit is sent to Camp Holabird. We carry in stock a 10-per cent reserve. I have about 40 trucks operating in the First Corps Area and am entitled to carry four engines in stock. An engine out of reserve stock is used to replace the unserviceable one, and the old engine goes back to the central repair-shop. The stock is replenished by requisitioning for serviceable units. The authority for drawing that assembly is a copy of a bill of lading, showing that the old unit has been returned. That is a very

[1] This paper was printed in THE JOURNAL for November, 1927, beginning on p. 539. The abstract is reprinted herewith. The author is a Service Member of the Society and is property and maintenance officer, Army motor service, Quartermaster Corps, First Corps Area, Army Base, Boston.

[2] M.S.A.E.—Engineer, operation and maintenance of automotive equipment, American Telephone & Telegraph Co., New York City.

strict ruling. Another very strict rule is that we do not strip the old units of certain parts that we would like to keep. That spoils the plan for the central repair-system if we rob the units.

The organization at Camp Holabird investigates costs very carefully and has proved that the present system is the most economical. A very accurate record of cost is kept on all units and parts repaired or rebuilt; in fact, the average cost of practically every operation is known.

MR. GLYNN:—Do you consider the interest on your investment? You have a considerable extra investment. Are your transportation charges figured in? Did you consider these points in your answer?

LIEUTENANT THEE:—I did; but military supplies cannot be considered in the same light as supplies needed in civil life. But in our various depots, such as the Army bases in Chicago and Boston, as well as others, a certain reserve stock is necessary in cases of emergency, for such supplies as shoes, blankets, overcoats and the like. We also have to carry in reserve a certain number of vehicles. So far as the interest on the money invested in equipment is concerned, we are operating on surplus war materiel that we are putting to good use rather than disposing of it. If we disposed of our standard Class-B 3-ton trucks that are in surplus stock now, what could we get for them? Perhaps $800 to $1,500 each, and they cost $5,000. As to freight charges, I can ship a standard Class-B engine from Boston to Camp Holabird at 38 cents per 100 lb. The engine weighs about 600 lb. and it costs say $2.25 to send it to the Camp. If that engine were rebuilt in a civilian shop or in the Army shops in Boston, it would cost much more than the difference in cost of the freight. My great trouble in Boston is to get funds for local purchases in cases of emergency. We try to anticipate our wants and requisition everything from Camp Holabird.

METHODS OF SHIPMENT

F. C. HORNER[3]:—What system do you use in handling transportation between your main supply base at Camp Holabird and various Army posts throughout the Country? Do you use freight transportation altogether when time permits and use express transportation when the case is urgent, or do you sometimes send a motor-truck from Boston to Camp Holabird with a number of units?

LIEUTENANT THEE:—A motor-truck is never dispatched from Boston to Camp Holabird to transport units or supplies. Rail or water transportation is used. A shipment in full carload lots goes by rail because the railroad reaches the Camp direct. If it is shipped by water, we have to haul it from the docks to Camp Holabird, a distance of about 5 miles.

As to shipment by express, in one instance we had a certain make of engine sent by express because Army maneuvers were in progress, in which case we have to accomplish things without regard to cost, this being one reason that the Army is so badly criticized at times. Economy is not what the officers in charge of maneuvers are trying to accomplish, they are concerned in getting results at the proper time and work under the same conditions as if an emergency existed.

Complete vehicles are never transported or driven to central repair-plants to be rebuilt; they remain at the operating centers, and units and assemblies only are shipped to the repair centers. In the event that a vehicle becomes so unserviceable that the cost of repairs will exceed 35 per cent of its original cost, the vehicle is surveyed and sold by the salvaging officer.

MR. HORNER:—Do you sometimes send complete cars that have been overhauled over the road to Boston, for example, or are they sent by steamer?

LIEUTENANT THEE:—Usually we send them overland from Camp Holabird to Boston, as a load can always be provided. If there are no supplies to be transported, vehicles are shipped in carload lots by rail.

DEPRECIATION OF EQUIPMENT

W. H. EDMUNDS[4]:—You say you have some equipment that is 10 years old. How great has been its depreciation?

LIEUTENANT THEE:—It is difficult to state how much our equipment has depreciated, as unserviceable units are constantly being replaced. With our large supply of spare parts on hand, and since the work is being done by soldier labor, I really think that it is economy to continue operating those vehicles for that length of time. Consider our standard Class-B 3-ton trucks. What is there that is obsolete about them? The center of gravity may be somewhat high and the fuel economy is not so good as it might be, but there is not much difference between their performance and that of a more modern truck. The designs have not changed radically. We are not having trouble with the engines or the transmissions or the differentials. We have not purchased a single solid tire for the standard Class-B 3-ton truck since the war, as we still have a supply of them left. During the war, the Ordnance Department used Cadillac engines in its tractors and, since tractor engines have to operate at a higher speed, the clearances of the piston-rings and other parts are greater than those of passenger-car engines. We had a large supply of Cadillac engines and converted them so that we have had to purchase very few Cadillac-engine parts. We are buying Cadillac fenders here and there because the mortality on them is high.

ECONOMIC CONSIDERATIONS

J. F. WINCHESTER[5]:—The paper sets forth, in great detail, a method of training soldiers to take care of the motor equipment the Army is operating. To my mind, the greatest value which comes from such work is that it employs the soldier in useful pursuits during the time of his enlistment and turns him back to civil life better equipped to solve the problems of making a livelihood. Such training also serves to create a reserve nucleus that will be ready to answer its Country's call in case of necessity, which, if we are to profit from the World-War example of unpreparedness, is no small item. Useful pursuits and training of this character in any branch of the Army service tend to increase the respect of the average civilian for the service, which is an important consideration.

Questions are raised by previous discussers as to the economic possibility of having the work done more cheaply by outside or private concerns than by the Army itself, and the old argument is advanced by Army representatives that cost is not a consideration and that it is a slogan of the Army that "An objective should be reached regardless of the cost." This may be proper

[3] M.S.A.E.—Assistant to vice-president, General Motors Corporation, New York City.

[4] Vice-president and general manager, The Denver & Interurban Motor Co., Denver.

[5] M.S.A.E.—Superintendent of motor equipment, Standard Oil Co. of New Jersey, Baltimore.

during war, but it certainly is not applicable to peace-time pursuits. In times of peace, the object should be "Results at the minimum cost." A policy of this character relieves the taxpayer and creates confidence in his mind toward the service. As time goes on and the present generation passes, if no wars have occurred the service will find that it will need just such confidence in future years.

Aside from the training feature, considerable stress was laid on the system of unit repairs. Having been one of the original advocates of this system, and having had the opportunity to apply it in our operation over a period of years, I have every reason to believe it to be sound practice. But I do not believe it to be economically sound to service such a large area as Camp Holabird does, and this opinion was expressed to Major McClure and his subordinates at Washington more than 2 years ago when I was called there to give them the benefit of my experience. It was stated, however, that the appropriation or funds did not exist that would permit the distribution of machines and parts to the other corps areas at that time. The logic of this recommendation is borne out by Lieutenant Thee's quotation of 1200 units overhauled per month, the average weight being 600 lb., at an average freight rate of 38 cents per 100 lb. or a freight bill of $2,736 per month. Making an original appropriation to get this work out into the different corps areas would save a large portion of this freight bill and result in other savings, such as reductions in clerical forces, in red tape, in crating costs and in reserve equipment. I am unable to say just what effect this would have on personnel training, but my experience leads me to believe that it could be carried on as well with direct benefit to the Army personnel, for it would be necessary in a smaller operation to train men to diversified operations, which would make toward greater efficiency in time of emergency.

The Army is to be congratulated on the fine personnel-training work it is doing along mechanical lines. Its personnel must awaken to the fact, however, that where no emergency exists a patriotic and loyal endeavor should be made to conduct all operations on economical commercial lines.

LIEUTENANT THEE:—I agree with Mr. Winchester that the objective should be "results at the minimum cost" in times of peace, and I can produce all the desired evidence to prove that a policy is adopted by the Army to repair its motor transportation that relieves the taxpayer and creates confidence in his mind toward the service.

By servicing such a large area, Camp Holabird, as well as the various other reconstruction parks located at Camp Normoyle, Tex.; at Jeffersonville, Ind.; and at San Francisco, can make repairs on a large-production basis. By covering such large areas, sufficient quantities of similar units are received for repairs, and individual departments can be set up and kept busy repairing or reconditioning only one kind of unit. For example, it would not be economical to set up a cylinder-grinding or upholstering department in Boston, as there is not enough demand for this class of work to keep even one man busy and the machinery could not earn the interest on the investment and the rental of floor space. Quoting from the paper on The Transportation Service[6], by Brigadier-Gen. F. H. Pope:

> To indicate the extent of the maintenance work in these reconstruction shops alone, during the fiscal year of 1927 more than 2700 vehicles, 110,000 units, and some 3500 miscellaneous jobs were handled at a cost of approximately $522,000 which would have cost well over $1,000,000 if handled commercially. The work of all the other repair activities such as the service shops, including repairs overseas, was about three times greater, with corresponding savings over commercial cost.

Mr. Winchester quoted me as saying that the average weight of each unit is 600 lb. I stated that a standard Class-B truck-engine weighs 600 lb. The average weight of a unit is much less than this. Assuming that each unit did weigh 600 lb., according to Mr. Winchester's figures the cost of the freight bill on each unit would be $2,736 ÷ 1200, or approximately $2.28. The amount actually saved by sending units to large repair centers, such as Camp Holabird, on each unit weighing as much as 600 lb., an engine, for example, is much more than $2.28 when it is known that, to rebuild an engine properly, all bearings must be refitted, the crankshafts and cylinders reground, and the timing-gears, pump shafts and the like replaced when worn beyond repair. To attempt to make such repairs in small shops such as the one located in Boston would require highly trained skilled mechanics and a large stock of spare parts. Highly trained and skilled mechanics are not available in the Army to any great extent. Furthermore, mechanics in the small shops could not be permitted to specialize on certain classes of work the way they do at the large repair centers, because there is not enough work of one class to keep them busy operating only one machine such as a cylinder grinder, crankshaft grinder, single-point boring-bar for refitting crankcase bearings, and sewing-machines for repairing seat cushions and upholstery.

When unserviceable units require repairs that are not beyond the facilities of the small shops, they are made locally. Unserviceable units are shipped to the large repair centers only when they require complete rebuilding and repairs that are beyond the capabilities of the small shops.

[6] See *Quartermaster Review*, January-February, 1928, p. 3.

Sun Power

OF all astronomical bodies the sun is by far of the greatest immediate concern to human beings. Literally in him we live and move and have our being. Few realize that every square yard of the earth's surface exposed to direct sunshine receives energy at the rate of more than 1½ hp. and that the whole earth itself receives from the sun heat at such a rate that if converted into doing work it would represent the equivalent of 230,000,000,000,000 hp. With the exception of a few experimental solar engines once set to work for irrigation purposes in arid regions, man has practically made no attempt to convert solar rays directly into mechanical effort. Perhaps at some time in the future when oil is running low and coal is selling at $100 per ton man may learn to tap profitably this abundant source and utilize this tremendous power.—Prof. H. T. Stetson in *Harvard Alumni Bulletin*.

Symposium on Metal Aircraft Construction

SEVERAL papers were presented in the symposium on Studies in Metal Construction at the Aeronautic Meeting last October. Two of these, Metal Construction of Aircraft, by Commander R. D. Weyerbacher,[1] U. S. N., and Selection of Materials for Aircraft Structures, by J. A. Roché,[2] were published in the November, 1927, issue of THE JOURNAL, pp. 489 and 494. Papers by Charles Ward Hall and W. B. Stout and printed herewith, together with oral and written discussion.

Commander Weyerbacher enumerated in his paper the limitations of wood and the advantages of metal as structural materials and drew the conclusion that weight can be saved and greater reliability secured with metal construction. He outlined and illustrated the use of metal, chiefly aluminum alloys, for fittings and structural parts, and described a novel expedient for the production of pressed-metal parts in small quantities at moderate cost. Emphasis was placed on the necessity for preventing corrosion by avoiding contact between dissimilar metals and by thorough application of protective coatings to both interior and faying surface.

Mr. Roché presented formulas giving rational criteria for the design of airplane members and for the selection of the most suitable material. He also gave tables of the relative strength-values of the several materials, including spruce, aluminum alloy, chromium-molybdenum steel, and heat-treated chromium-molybdenum steel. These show which materials are best for various parts of the structure and how much weight it is wise to add for a given increase in the output of the powerplant. Physical properties of the materials were considered with relation to their functions, and indices were given classifying them in the order of their merit for tension and compression and for beams and columns. The paper gives conclusions showing which materials are most suitable for various vital parts of airplanes of different types.

Abstracts of the other papers are printed herewith beneath the respective titles. The discussion is general on the several papers and deals with the desirability of cooperation by Government bodies and manufacturers in making available detailed information on properties of metals in the forms in which they are available; the relative advantages of riveted and welded joints; the necessity for designing the structures of metal airplanes with particular reference to the fact that metal is to be used; the importance of making the units into which the airplane can be dismantled and reassembled in the field sufficiently small for convenient handling and transport; the suitability of metal for rapid production in event of war; various treatments for protection against corrosion; and simplicity and low cost of repairing.

Methods of Building Metal Airplane Structures

By CHARLES WARD HALL[3]

USEFUL load-carrying capacity is a measure of the comparative value of two airplanes of the same size, having identical powerplants, speed, rate of climb and other flying characteristics. It seems to be feasible to combine in the same airplane both the greatest ability to carry useful load and the least cost of construction.

Blanked and pressed metal work offers substantial advantage to the extent that parts, particularly subassemblies, can be made directly by machine in complete units ready to set in the final assembly.

The author shows and describes the methods followed by his organization in forming the members, building the frames and assembling the units of metal aircraft. Trusses are blanked and the web members pressed to ¾-circle form. Dies for long members are variable in length by being made in pieces that can be removed or inserted as desired. Flanged-tube sections are employed for truss chords. Members are secured together by riveting, the rivets being readily accessible for machine setting and punching.

Flanged tubing for truss structures is made by drawing a strip of sheet metal through a die that forms it into a circular or an elliptical section and leaves a desired form of flange along the edges to which other parts can easily be fastened. Hollow-bulb angles also are made from drawn strips and have various uses. They form convenient conduits for electric wires.

By the construction described, a high ratio of strength to weight is obtained. With economical design in metal, the load-carrying structure need not exceed 10 per cent of the gross flying-weight, and 40 per cent of the gross weight can be pay-load. In reasonable quantities, the cost of production of such airplanes should be lower than is possible with wooden structures.

Use by the Navy of a number of flying-boats and pursuit airplanes of this type for 3 and 4 years, and inspection of similar wings built for the Navy in 1920 and 1921, show that corrosion offers no problem.

THE subject of constructing airplane frames of metal has been approached from many different viewpoints, and one of the results has been a great diversity of methods. To cover the entire field and to make detailed comparisons of the relative merits of the various types of construction, with regard to cost, durability, and effectiveness, as measured by the ratio of the weight to the strength, would require a long time.

[1] Manager, Naval Aircraft Factory, Philadelphia.

[2] Senior aeronautical engineer, materiel division, Air Corps, Wright Field, Dayton, Ohio.

[3] M.S.A.E.—President, Hall-Aluminum Aircraft Corporation, Buffalo.

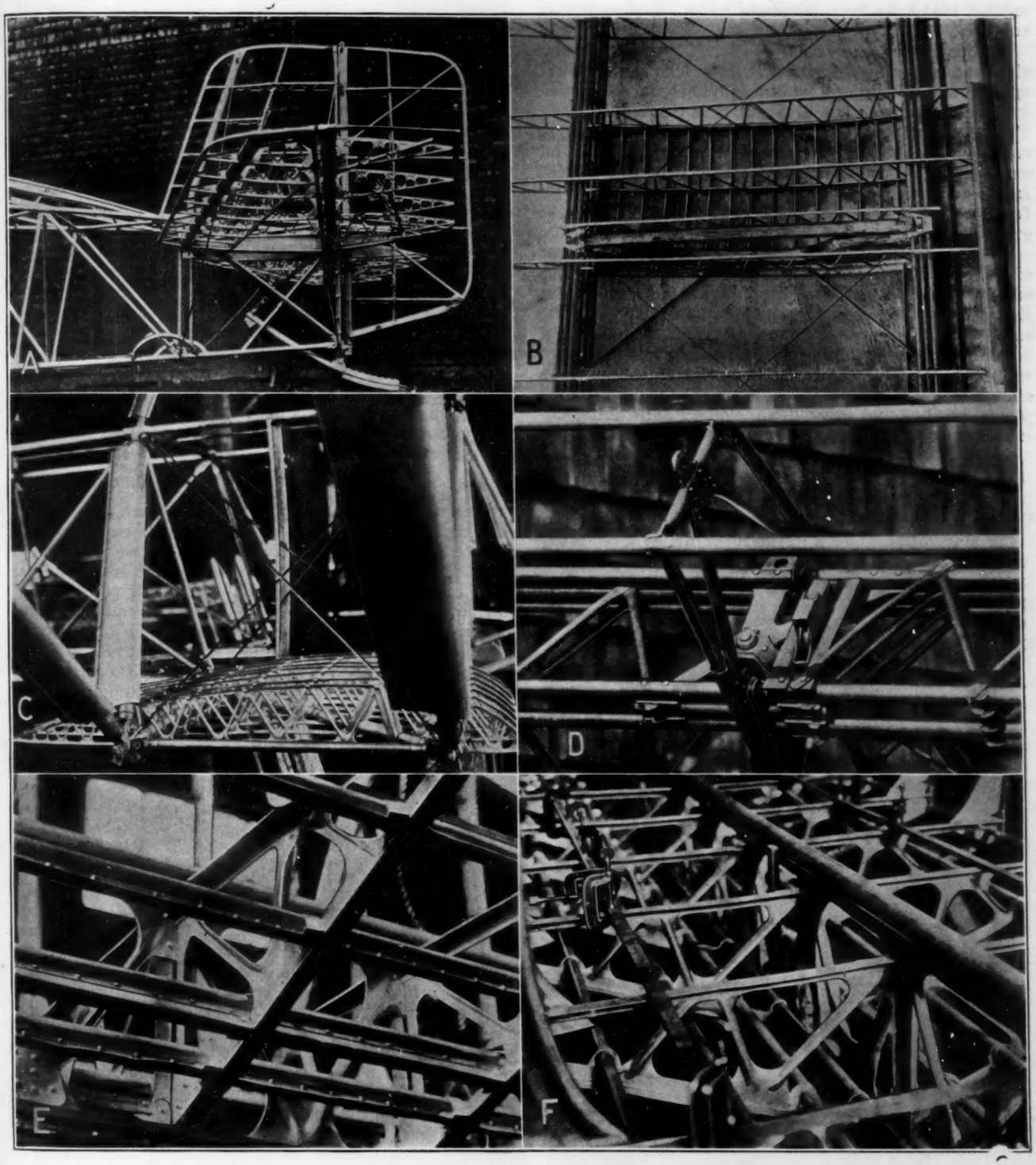

FIG. 1—DETAILS OF BLANKED AND PRESSED SHEET-METAL CONSTRUCTION OF FLYING-BOAT AND NAVY PURSUIT AIRPLANE

(A)—Complete Set of Flying-Boat Tail Surfaces of Pressed-Rib Type. All Ribs, though Varying in Length, Were Produced with the Same Set of Interchangeable-Parts Dies

(B)—Application of Hollow-Bulb Angle to Walkway on the Wing and for Supporting the Smooth Sheet-Metal Nose-Stiffener

(C)—Blanked and Pressed Wing-Ribs Closely Spaced for Walkway on Lower Wing at Side of Fuselage of Flying-Boat

(D)—Truss Built of Flanged Tubing Formed by Drawing Sheet-Metal Strips Through a Die, Leaving Longitudinal Flanges to Which Other Parts Can Be Fastened Easily

(E)—Floor Frames of a Flying-Boat. Each Frame Is Made of Two Pieces in the Form of a Warren Truss Blanked in One Die and Pressed in Another

(F)—Keel of Flying-Boat Hull Showing Chords of Pressed Warren Trusses Formed to Angle Section and Webs Formed Approximately to Parabolic Section

I shall therefore touch upon only a few phases of this subject that have been developed under my direction or control.

The comparative value of two airplanes of the same size and arrangement, having identical powerplants, speed, rate of climb, and other flying characteristics, may be measured by the useful load carried by each. Two such identical airplanes that vary only in the type and weight of the structural framework may differ greatly both in the useful load that can be carried and in the factory cost of construction; and it seems to be feasible that the same airplane should combine both the greatest useful load capacity and the least cost.

Cost, obviously, comprises the raw material, the labor of shaping the parts, the labor on each of the various sub-assemblies, and the labor of the final assembly, plus that pervasive and ever-present item, overhead. To the extent that parts, and particularly sub-assemblies, can be made directly by machine in complete units ready to set in the final assembly, as compared to building-up similar sub-assemblies by fastening together many pieces, blanked and pressed work offers substantial advantages.

Forming and Assembling Hull Members

Fig. 1-E shows the floor frames and Fig. 1-F shows the keel of the hull of a flying-boat, each of the frames being made of two pieces in the form of a Warren truss blanked in one die and pressed in another. The chords are thus formed to angle section and the webs to approximately parabolic section. Assembling them to the keel is accomplished by two rivets to each top chord and by three rivets and a gusset-plate to each bottom chord. The rivets are not subject to tension and operate under shearing loads only; and all of these are readily accessible for punching or setting by power or by hand, as preferred. The rivet holes are preferably punched while temporarily assembled with clamps.

The keel is also a Warren truss, blanked and the web members pressed to a ¾-circle form from one piece of sheet metal that extends from stem to stern. The top chord of this truss is formed by riveting a flanged-tube section to it, the rivets being readily accessible for machine setting and punching. The bottom chord consists of the near-by bottom skin, a drawn garboard-strake section, and a U-shaped cover-strip, all simultaneously secured by a single row of rivets.

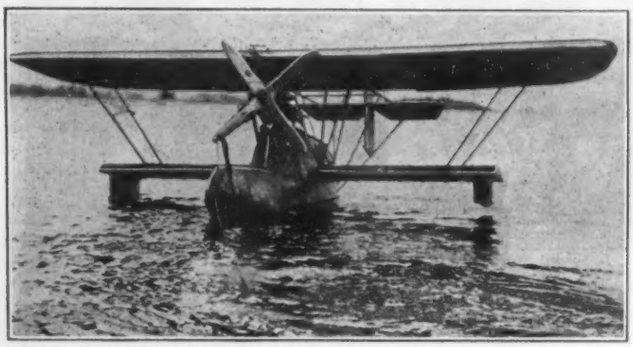

Fig. 2—Flying-Boat Complete After 4 Years' Service

This Weighs, Empty, 530 Lb., of Which the Hull Represents 68 Lb. The Useful Load, Consisting of Two Men and Fuel and Oil for 5 Hr., Weighs About 440 Lb. The Length of Service, Including Some Fairly Hard Landings, Indicates That Strength Is Obtained with Very Light Weight and Proves That Corrosion Is No Problem

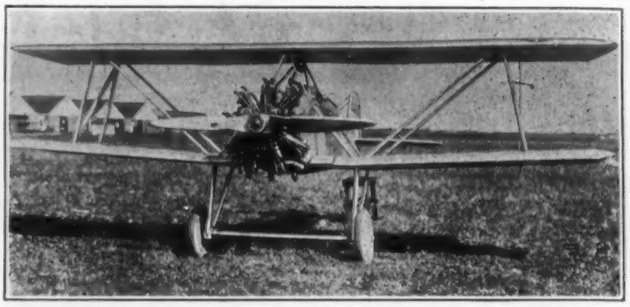

Fig. 3—Navy Pursuit Airplane Ready for Flight

The Complete Framework Weighs 167 Lb., as Compared with 361 Lb. for the Corresponding Wooden Airplane, or 46 Per Cent as Much. Airplanes of This Construction Have Been in Use by the Navy for 3 Years and Are Still Being Flown

The floor frames differ from those amidships in beam and in dead rise as the bow is approached. This does not require a series of sets of dies, for all these frames have been made from a single die which is adjusted by pulling out two or three parts at one end and substituting other parts.

Sheet-Metal Gives Strength with Light Weight

Sheet-metal is one of the cheapest forms of structural metal, and the labor cost of producing so complex an assembly as a trussed floor-frame, complete and ready for use, through stepping but twice on the treadle of a press requires no elaboration. When properly designed, such a structure is extremely light and supports an unusually large percentage of useful load. Fig. 2 shows a flying-boat complete, after 4 years of service. This weighs, empty, 530 lb., of which the hull represents 68 lb. The useful load consists of two men and sufficient fuel and oil for 5 hr.; that is, about 440 lb. The 4 years' use, including some fairly hard landings, seems to indicate that high strength is obtainable with very low weight, and to prove that the much-talked-of corrosion problem is really no problem at all.

Fig. 3 shows a Navy pursuit airplane of this type of construction ready for flight.

Lightness of Wing and Aileron Structures

Figs. 4-A and 4-B show other examples of blanked and pressed sheet-metal structure; namely, a small wing-rib from a single piece of sheet-metal and of a larger rib in three sections; the nose, the center section between the spars, and the tail. Aileron ribs, with a collar for attaching to the torsion tube, are also shown in Fig. 4-A. Each section or unit is blanked at one operation and pressed in a second operation. Compound dies could be built to blank and press such parts in a single operation, but the quantities in production at present do not warrant so expensive a tool.

The wing spar is jig assembled as a Warren truss having several tubes for each chord and tubular web-members. The assembling of the ribs to such a spar consists in slipping each spar through the openings provided in the entire series of ribs, passing a clip around each spar chord and securing the clip to the rib by two punched and pressed rivets which are readily accessible. A complete wing-panel so assembled is seen in Fig. 4-C. This panel is of 25-ft. span and 44¼-in. chord, and comprises 92¼ sq. ft. of area; the weight, before covering, was 48 1/3 lb., or 0.524 lb. per sq. ft. The individual ribs weighed 3.9 oz. each.

These ribs are more closely spaced in Fig. 1-C to form

a sidewalk on the lower wing at each side of the fuselage, the covering consisting of smooth duralumin sheet, 0.024 in. thick, riveted directly to the rib chords. This sidewalk structure, consisting of spars and their joint fittings, ribs, leading edge, trailing edge, and covering, complete, weighed 0.75 lb. per sq. ft.

These airplanes were delivered to the Navy 3 years ago and are still in use, a fact that indicates that light weight is consistent with sufficient strength.

Other examples of pressed rib-work are the ailerons, weighing 2.6 lb. each, the fin and rudder weighing 0.59 lb. per sq. ft. and the stabilizer and elevator, shown in Fig. 4-D, weighing 0.57 lb. per sq. ft. That such light structures are not weak is shown by the view of these horizontal tail-surfaces in Fig. 4-E after carrying a sand load of 157 lb. per sq. ft. Such parts as the leading edge and the ribs have, in a number of trials, supported a 160-lb. man standing on one foot.

Fig. 1-A shows a complete set of tail surfaces of this pressed-rib type. The ribs, although varying considerably in length, were all produced from the same set of dies merely through an interchange of parts.

The weight of the complete framework of a Navy pursuit airplane in Fig. 3 was 167 lb., as compared with 361 lb. for the corresponding wooden airplane, the metal frame weighing but 46 per cent as much as the wooden frame. As stated before, these airplanes have been in use for 3 years and are still being flown.

The panel from one of a set of similar wings built for the Navy in 1920 and 1921 was included in the Navy exhibit at the Sesquicentennial Exposition at Philadelphia. Inspection proved the wings to be in good condition after 6 years, another demonstration of the fact that light-weight metal airplane-structures are not necessarily sensitive to corrosion.

Advantages and Uses of Flanged Tubing

A different type of truss structure may also be formed of sheet-metal by using a section that we developed 9 years ago. This is a hollow circular or elliptical section having two projecting flanges, as at the left in Fig. 5, and is called "flanged tubing." This tubing is produced by drawing a long strip of sheet-metal through a die. For many uses it has the efficiency of a round tube, and the added advantage that other parts can easily be fastened to the flanges. It may readily be curved to any desired outline. In addition to being used for rib chords, it has been flattened at the ends and used for

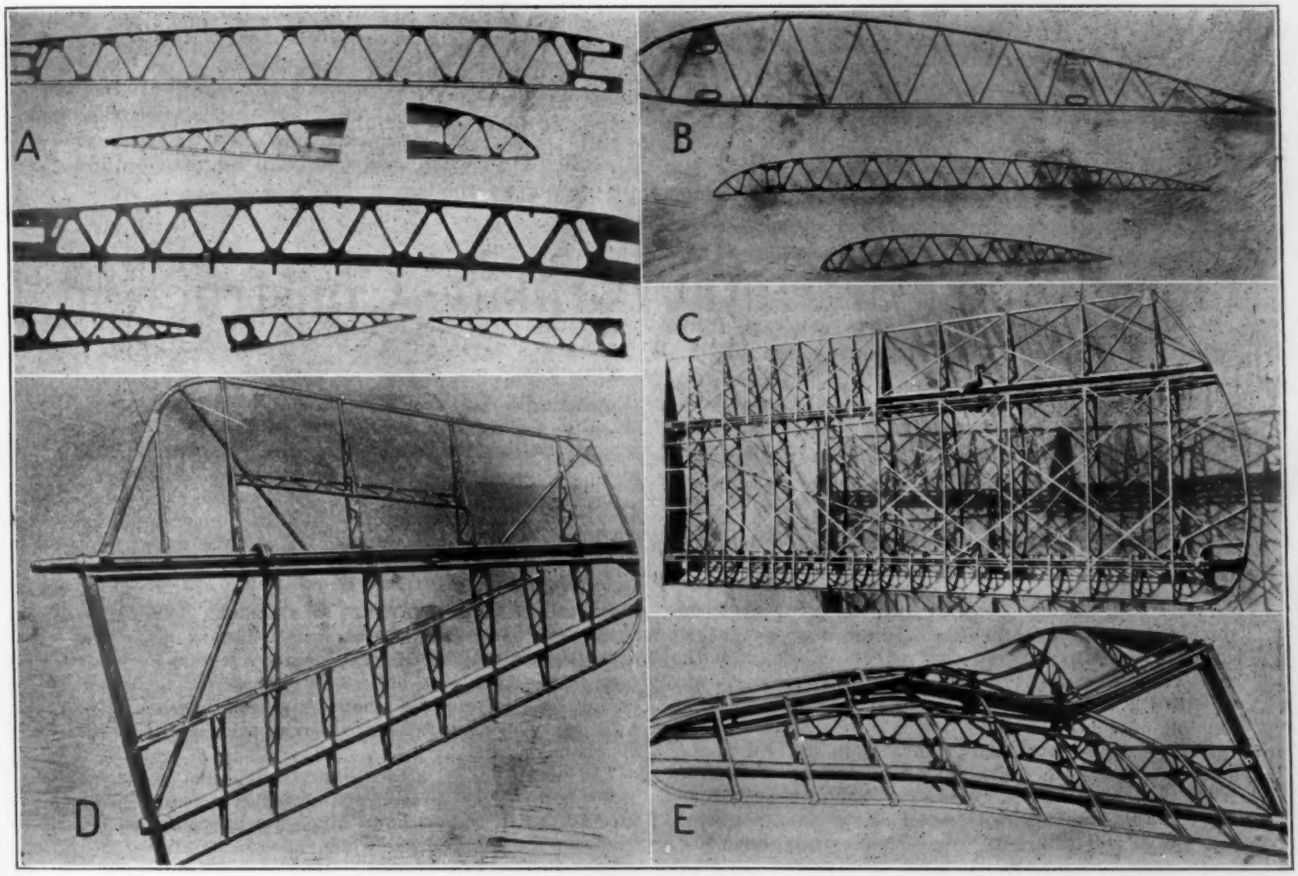

Fig. 4—Details of Wing and Stabilizer and Elevator Construction

(A)—Unassembled Middle and Edge Sections of Small Wing-Ribs, Each Section Blanked and Pressed from a Single Piece of Sheet-Metal in Two Operations. Also Aileron Ribs with Collar for Attaching Torsion Tube. Blanks Are Shown before Forming, as Well as Finished Stampings

(B)—Assembled Wing-Ribs of Different Sizes. Compound Dies Could Be Built To Blank and Press the Parts in a Single Operation if Quantities in Production Would Warrant the Expense

(C)—Complete Wing-Panel Formed by Assembling Pressed Ribs with Built-Up Spans. The Panel Is of 25-Ft. Span, 44½-In. Chord, and Weighs 48¼ Lb., or 0.524 Lb. Per Sq. Ft.

(D)—Stabilizer and Elevator Built of Tubing and Pressed Members Riveted Together

(E)—Horizontal Tail Surfaces After Sand-Loading to 157 Lb. per Sq. Ft., Showing that Such Structures Are Not Weak

rib web-members instead of the flattened-end round tubes; and also for fairing strips and their frames for fuselage covering. Another use is for the edging of seat backs and, in large sizes, as coaming for cockpits. Fig. 1-F shows it as forming the keel-chord member of a flying-boat.

Another useful section drawn from strips of sheet-metal is the hollow-bulb angle, also shown in cross-section at the right in Fig. 5. This has been used for the stringers of the bottom of flying-boats to which the skin has been riveted and also as reinforcing for the seat of a cockpit chair. Fig. 1-B shows its application to walkways on the wing, as well as for supporting the smooth sheet-metal nose-stiffener. Incidentally, the hollow bulb forms a very convenient conduit through which the electric wires may be run for night-flying lights or for operating wing-tip flares.

The walkway incorporated in the wing-panel is covered with smooth sheet-metal over these bulb-angle stringers. The panel, 3½ by 15 ft., when completely covered with fabric and doped, weighed 125.5 lb., or 0.985 lb. per sq. ft. Being the upper central panel of a biplane, it is the heaviest section. An outer panel, 3½ x 21 ft. of the same airplane, weighed, completely covered and finished, 116.62 lb., or 0.665 lb. per sq. ft. The entire wing cell, including the five main panels, two removable panels, four ailerons, and the interplane struts and wires, weighed, complete, 813 lb. for 840 sq. ft., or 0.97 lb. per sq. ft. In a commercial airplane having the same load-factors, but omitting various walkways that are required only for Navy purposes, the weight would reduce to 0.88 lb. per sq. ft.

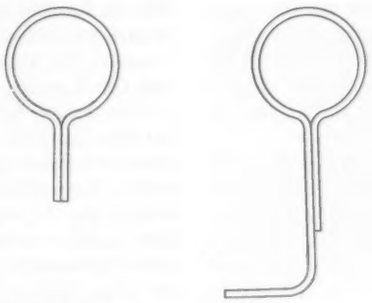

FIG. 5 — CROSS-SECTION OF FLANGED TUBING AND HOLLOW-BULB ANGLE

Tubing of Circular or Elliptical Section Having Two Projecting Flanges Forming a Truss, as Shown at the Left, and Bulb Angles Having an Angle Flange, as at the Right, Are Formed by Drawing Sheet-Metal Strips Through Dies. For Many Uses the Flanged Tube Has the Efficiency of a Round Tube, with the Advantage that Other Parts Can Be Attached Readily by Riveting to the Flanges. With the Ends Flattened, It Can Be Used for Rib Web-Members. The Bulb Angles Are Used for Stringers of the Bottom of Flying-Boats, for Walkway Support and the Like, and also Form a Convenient Conduit for Electric Wires

Reverting to the subject of pay-load, in many cases this does not exceed 25 per cent of the gross flying-weight. In such cases, the weight of the load-carrying structure is of the same order, the remaining half of the flying weight comprising the powerplant, the fuel, and the pilot. With economical design in metal, the load-carrying structure need not exceed 10 per cent of the gross flying weight, leaving a further increment of 15 per cent for pay-load, or a total of 40 per cent of the gross flying-weight as pay-load. In reasonable quantities, the cost of production of airplanes of the structural types shown should be lower than is possible with wooden structures, as wood is not so well adapted to quantity-production methods.

Duralumin All-Metal Airplane Construction

By W. B. STOUT[4]

PSYCHOLOGY of the public, as well as engineering structure and aerodynamics, is involved in commercial aviation. The public has confidence in metal.

With quantity production in view, the author and his associates considered costs of production as related to quantity and also costs of maintenance at airports and in the field, and chose metal as the material of construction.

Structural members are fashioned from sheet duralumin rather than from tubes and a type of construction was evolved that can be made with the minimum investment in tools, that is cheap to put together and that can be repaired with the smallest amount of equipment and labor.

For compression loads, duralumin has a great deal more strength for a given weight than has steel. It cannot be used, however, for compression members in combination with steel in tension members because of the difference in coefficient of expansion.

Advantage is taken of the rigidity of corrugated duralumin sheets to use them as wing covering in a way to form part of the structure and prevent torsion.

Strength of metal of a given analysis and heat-treatment can be determined within 5 per cent, and all duplicate members made of the same metal have equal strength. This is not true of wood and of wooden members.

Parts of a damaged metal airplane can be repaired readily with metal of the same thickness, quality and cross-section and the airplane made as good as when new.

Built-up sections of metal riveted together give warning of coming failure, whereas wood and tubular members do not.

The exterior of a duralumin airplane needs no painting or other protection against corrosion. The sheets used in the author's airplanes are polished before fabricating and are given no other finish.

WE are reaching a point in commercial aviation where something more than merely engineering structure and aerodynamics is involved; namely, the psychology of the public toward the vehicles in which they are beginning to fly. This psychology, as translated to the insurance companies and to others concerned in the operation of airplanes, requires a viewpoint of engineering that is more or less new and that must include the viewpoints of the public, some of them erroneous, perhaps, from a purely engineering standpoint, but nevertheless viewpoints as affecting the bases of design.

The public recognizes in metal something in which it has considerable confidence. It seems to be easier to

[4] M.S.A.E.—President, Stout Air Services, Inc., Dearborn, Mich.

get the general public to step up to and ride in a metal airship than in an airplane in which cloth is in evidence, in which vibrating wires are in sight, and in which perfectly good engineering may possibly seem to the layman to be not quite right.

In considering metal construction in our own particular line of work, we have had the public as much in mind as engineering problems. Beyond that, we have thought of the future of quantity production, of costs as related to quantity production, and of maintenance not only around an airport but in the field. So metal was chosen for the type of airplane that we are building at Detroit.

In building a metal airplane, the problem may be attacked in several ways and a controversy will continually be waged between one type and another. We all admit that some types are better for one purpose and some for another. I will merely give the analysis that we have followed for what it is worth, without by any means saying that it is a final analysis or is more than just the line that we have been interested in following.

Sheet Duralumin Fabricated Cheaply

We have used duralumin and have fashioned it from sheets, rather than from tubing or any similar structure, because originally we did not have money enough to do anything else. We had to devise some way of making a metal airplane with a tinner's brake and a $100 set of rolls. We made the first rolls, as I remember, of hardwood. In that way we evolved a type of construction that was cheap to put together, that could be made with the minimum amount of investment in tools, and, consequently, could be repaired with the smallest amount of equipment and labor.

We have used sections bent-up from flat sheet-metal of different thicknesses. These sections were tested in the testing-machine for column and tension loads, although tension loads are not so great a problem. Much higher tensile-strength can be obtained from steel per pound than from duralumin, but tensile strength is not the problem; the problem is column loads. With duralumin, the cross-section thickness for a given weight is two to three times that of steel and the column strength is in proportion, so that, for compression loads, a great deal more strength is obtained from duralumin, according to our analysis, than can be obtained from any high-tensile-strength steel.

One might say at once that it would be logical to make the compression members of duralumin and the tension members of steel, if he did not remember that the coefficients of expansion of the two materials are different and that a change of temperature from cold to warm might cause a considerable warpage and variation in the structure. For this reason we made a homogeneous structure by using the same material throughout.

Design To Utilize Rigidity of Metal

The laying-out of a metal airplane can be accomplished in two ways: by copying in metal an airplane that has been made of other materials, or by designing an airplane so as to take advantage of the qualities of the metal that other materials do not have. If a conventional biplane design, in which the torsional stresses are taken care of by trusses, is followed and a metal frame is built and merely covered with a metal sheet, the weight, from what we know now, will be greater than in the conventional method of building. But if advantage is taken of the rigidity of metal in the corrugated form, and if this form is used for wing covering as part of the structure, the weight is less than in the old method of construction, particularly for monoplane types. In the type we build, we use a thick cantilever wing, cover the outside of the wing with corrugated metal, and use the sheathing as a tube to prevent torsion. The problem with monoplane wings is not so much in their strength as in their rigidity. It is easy to design spars that will carry calculated loads, but is not so easy to make a monoplane wing that will not flutter under certain conditions. The torsional strength of the wing must be extreme. Metal has the great advantage that, by using the skin as part of the structure, a very rigid wing is obtained.

Duplicate Metal Structures Uniform in Strength

In 1917 we built wings of veneer. The wing can be built as light as or lighter than a conventional cloth-covered wing, if the veneer is used as the structural part of the surface, but veneer is useful only as a tension material. Being flat and thin, it has very little strength under compression, whereas the sheathing of corrugated metal has considerable column strength. If it is put on the wing properly, the skin or surfacing function has practically no weight when the skin is used as the structure. Following on down through the airplane, we have used simple cross-sections of known strength.

Another feature of metal construction is that metal is a determinate material. Wood cannot be inspected with certainty. If several pieces of spruce are placed side by side, no wood expert can tell by looking at them which is the strongest. The only way the strength of a piece of wood can be determined is by breaking it, and then it cannot be used. With metal, if the kind of material and the method of heat-treatment are known, its strength can be determined within 5 per cent. When designing a roof truss for a building or for a bridge, the metal is depended upon for certain strengths and certain factors of safety. For this reason, we have favored metal for airplane structures. When we build a truss, we can tell very closely just what the truss will stand. When others are built like it, we know that they are duplicates of the original; whereas the different structure of each piece of wood makes each wing differ in strength from the others.

Original Condition Restored by Metal Repairs

Another point, which relates to maintenance, is not obvious at first. If an airplane of the conventional wood type is repaired, it is a repaired job. A piece of wood is spliced or it is replaced. The new piece may be of the same kind of wood as the original piece, or the pilot may be caught out where he must put in a broomstick, or a piece of pine or basswood. The airplane gradually becomes a patched-up job, or what we call "hay wire." Metal structures can be repaired in only one way, which is by putting them into their original condition. If anything happens to a metal airplane, corrugated metal of the same thickness, quality and cross-section is riveted together with the same size of rivets; and the airplane is as good as it was originally.

We had an instance of this with an airplane that was sold to the Standard Oil Co. last spring. The day after it was delivered a Chicago hurricane picked it up from the field, carried it a block, and hung it by the aileron wires on a cross-arm of an electric-light pole. It took 5 hr. to get it down and drag it back to the field. No

repair parts were in Chicago and no local mechanics who knew anything about repairing it; but 4 days later the airplane was flying and performing its usual routine of work carrying passengers. It was in exactly the same condition that it was in when it first came out of the factory.

Built-Up Sections Warn of Failure

The main beam of the wing is built up of sections riveted together, instead of using tubing. A single length of tubing of any kind, whether it is of steel, duralumin, or any other material, can give way without warning. In a piece that is built in sections and riveted, and in an entire structure built on that principle, if anything is weak, the weakness will be made manifest by a loosening of some part and a warning will be given. So, after a particular type of airplane has been flown for a few months, if such parts are found and the gussets, or whatever is necessary, have been increased in strength, there need be no fear of the type, because everything is in duplicate all the way through.

We use three spars for the same reason. If in military work one of them should be shot away, the airplane could still fly home with the other two. All parts are worked out in duplicate. The main spar section of a 19-in. test-column weighs 17 oz. and will support 13 tons in a column load.

One interesting feature of the design we are using is that the entire exterior of the airplane is polished. It is the natural finish, not nickel-plated. The sheets are polished before the airplane is fabricated.

Psychology of the public toward the metal airplane has been very interesting. Last June some of us bought one of these planes and put it on the field at the Ford airport to carry passengers in sightseeing trips over Detroit. We have not made a sales effort to sell rides, yet in 14 weeks, beginning June 1, 14,000 passengers were carried over Detroit on sightseeing flights at $5 apiece. There is a something in the appearance of the airplane that makes the public willing to ride; without salesmanship, the people come out and request it.

I believe that metal construction is basically right for commercial airplanes. It is almost necessary for any type of seaplanes. The development of the art from now on will depend, naturally, on the efforts that those in the aviation industry put into it and on the general commercial development of aviation as it passes from one stage to another.

THE DISCUSSION

Chairman Alexander Klemin[5]:—In the future, I think, all constructors will give more and more attention to the metal construction of commercial airplanes, and they will have to follow the lines of thought that Mr. Sikorsky has just disclosed to us.

Starr Truscott[6]:—The general feeling seems to be that metal construction is the coming thing, that wooden construction is passing, and that there is not much chance of reviving it. One of the things that seems to be needed, however, is more detailed information as to the properties of the material in the forms in which it is available. We are endeavoring to obtain that information through the cooperation of the various Governmental bodies and the manufacturers. It will be only a short time before data of that kind will be available so that persons who are taking up the problems of metal design for possibly the first time, or in an experimental way, will be able to proceed with considerable confidence. The response of manufacturers to inquiries as to their methods of assembling and as to new products more suitable for the metal construction of aircraft has been most promising.

W. G. Brown[7]:—What are the possibilities of getting an aluminum alloy that could be welded so as to simplify construction, as is done with steel?

Riveted versus Welded Joints

W. B. Stout:—One answer to that question, at least with regard to the alloys that we have at present, is that when an alloy is heated to a certain temperature it separates into its original components. I imagine that it would be possible to weld a clock spring, but when it has been welded, it is no longer a clock spring. That is true of duralumin, as it is now. It can be welded, and makes a very nice weld; but it is an aluminum weld, has the strength of aluminum, and will corrode. It returns more or less to its original state. In some cases, it can be heat-treated and will retain its form, but in large structures that is almost impossible.

There is also the question whether a weld is simpler than a riveted joint. I know of no way of inspecting a weld. There is no way of finding out whether it is a good weld, except from the man who made it and "he won't tell," especially if the weld is bad. When welders apply for positions, they are given test pieces to weld. When the welds are tested in the testing-machine, if they all pull to their prescribed limits, the men get the jobs. When a man has a job, he is not required to make such good welds, so he begins to slip. Unless the human element is checked very closely, I believe that, as the production increases and the men have been employed longer, welded joints will give more trouble than riveted joints.

Another advantage of a riveted joint is that it will always give warning of failure; and in the air it is important to have a little warning. In one instance we built a riveted engine mount for an original Liberty-engined airplane. Its weight was less than that of a steel-tube mount but it was still in good condition after 2000 hr. of engine operation. We had made only two changes on that mount since it was put on. After the engine had run for about 50 or 75 hr., the rivets in the gussets, at two points on the mount, one on the right and one on the left side, had become loosened from the vibration, so larger gussets were put on at those points each having two more rivets. But we got the warning, made the change and then ran for 2000 hr. with no trouble. I doubt whether a welded mount would have given any better service. So, when the simplicity of welding is spoken of, merely visual simplicity is meant. In production, a riveted joint is safer, and I think cheaper.

Hon. Edward P. Warner[8]:—It seems clear that.

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[5] M.S.A.E.—Professor of aeronautics, New York University, New York City.

[6] M.S.A.E.—Aeronautical engineer, National Advisory Committee for Aeronautics, City of Washington.

[7] M.S.A.E.—Assistant professor of aeronautics, Massachusetts Institute of Technology, Cambridge, Mass.

[8] M.S.A.E.—Assistant Secretary of the Navy for aeronautics, City of Washington.

whatever the argument may be about the best method of assembling a given structure at present, those who defend the use of wood are fighting an ultimately losing action. Whatever the advantages of wood for certain purposes may be, metal is making steady headway. I can recall no case in which a manufacturer who has adopted metal construction as standard practice has subsequently returned to wood.

One of the reasons is psychological, as Mr. Stout has said, and is by no means unimportant. We who work directly with airplanes may have fallen under the spell of the peculiar virtue that is supposed to inhere in a material so generally used in other engineering structures. An important favorable psychological reaction may also exist on the part of passengers.

Another reason still more significant for the growing popularity of metal seems to be its great adaptability. Mr. Roché has given figures on the specific weight and specific modulus of elasticity of steel, duralumin and spruce which have shown a fairly even distribution of honors on a purely statistical basis. I do not believe, however, that a statistical basis of comparison suffices for a fair rating of the relative merits of metal and wooden structures. Metal is so adaptable, so capable of being worked into especially efficient forms suited to particular needs in a particular structure, that the only possible basis of comparison is a direct balancing of the weights of complete subassemblies in metal and in wood.

Another important point referred to by Mr. Stout is the necessity for designing the structures of metal airplanes with particular reference to the fact that metal is to be used. As Mr. Roché has pointed out, if a geometrical similarity of section is preserved, we shall get a shallower section, and a shallower wing and air-foil in metal than in wood; yet we know that, when an airplane is designed originally from the ground up in metal, the conventional practice is to use thick sections and cantilever or semi-cantilever wings; that the use of internal bracing is more common in the metallic than in the wooden structure.

Dangers to be Guarded Against

Perhaps there are two dangers in this connection. The first is that airplanes, occasionally, have to make landings in small fields and suffer damage due to errors of judgment on the part of the pilots. If the damage is very severe it is frequently desirable that the airplane be transported to the factory. Although a metal airplane can frequently be flown home in a damaged condition, occasions will arise when that cannot be done and when repairs cannot be made on the spot, such as would be made if the materials were wood, fabric and wire. It is important, therefore, that metal structures be designed so that the units into which they can be dismantled and which can be reassembled in the field be not too large.

If metal construction becomes universal in the form in which it may prove to be most efficient, it may be necessary to develop an entirely new technique of handling airplanes on the ground. To secure the best possible ratio of strength to weight, sections may be so light and formed into assemblies so elaborate that the structure will not stand the rough handling that has been common with the wooden airplane.

To the services that must design and build airplanes with reference to their possible ultimate use in war, the use of metal is particularly interesting because it is undoubtedly better suited for putting airplanes into large-scale production in a comparatively short time, with small labor expenditure and at relatively low cost. This in itself would be an all-sufficient reason why anyone who is interested in the military use of aircraft or has confidence in the future expansion of the commercial market for aircraft ought to give special attention and preference to a material that is best suited to mass production and to the ultimate introduction into the aircraft industry of those methods of construction and assembly that have been so successful in bringing the cost of automobiles down to a figure well below the cost per unit of weight of the raw material that we employ at present in most of our airplanes.

Heat-Treating Duralumin Prevents Corrosion

Irving I. Chairman[9]:—I should like to call attention to a fact with reference to corrosion. At College Point we heat-treated all the steel tubing parts that entered into the construction of the Davis-Douglass airplane to 2000 deg. fahr. in an electric furnace, and the different parts, which were later tested with salt water, absolutely did not corrode. This shows that we need not fear corrosion and its consequences when the airplanes are left out on the water or in the weather at airports. It requires only experience with regard to how all the parts should be heat-treated and then such heavy parts will not be necessary.

G. Betancourt[10]:—Anodic oxidation of duralumin, in addition to protecting the surface, greatly improves the appearance of the work. The oxidized surface of the metal becomes an integral part of the material and resists tool marks and scratching better than any other thin protective coating does. Furthermore, no weight is added to the material. The beautiful dull-silver effect gives the work a decided character by making it seem permanently finished. However, with the advent of Al-clad and the prospect of new light alloys having more permanent crystalline structure, the anodic process, which is costly, will become unnecessary.

Elaborate Treatment Against Salt Water

B. C. Boulton[11]:—The question of corrosion should not stop here. I can understand how Mr. Stout's airplanes might not need much protection except polishing, because, in general, they have been subjected to fresh-water treatment, but I gather that Mr. Hall's airplanes have been anchored in salt water. We have found from experience that it is necessary to resort to a very elaborate system of treatment of duralumin parts to prevent corrosion. In our hull construction, the parts are treated with bitumastic and they are then painted with aluminized varnish or enamel. On other parts of the airplane, the wings, for instance, we have found it necessary to use different experimental finishes. On the ribs, we use an iron oxide. First, we treat the ribs anodically, then use an iron-oxide finish, and then three coats of aluminum enamel. This treatment seems very elaborate, and I cannot understand how other people have found it possible to eliminate almost all finish.

The ribs of our airplanes are made of metal 0.014 in. thick, so we have the problem of the corrosion of thin metal. I do not think that thin metal corrodes more

[9] Airplane engineer, New York City.

[10] Engineer, Aircraft Development Corporation, Grosse Isle, Mich.

[11] Chief engineer, Loening Aeronautical Engineering Corporation, New York City.

rapidly than thick metal, but the percentage of corrosion is higher; that is, if 0.003 or 0.004 in. of the thickness is corroded away, one-third or one-half the metal may be lost. The Naval Aircraft Factory and some other constructors are, in general, following our methods. We are building airplanes for the Army and the Navy, and these services are in substantial agreement with us.

New Process Produces Rust-Resisting Coating

CHARLES W. HALL:—It is fairly well understood that if metal is not wet it will not corrode. If it is kept in such condition that, when water is drawn against it, the water does not spread out and wet it, it cannot corrode. A greased surface has this effect on water. Any greasy surface will shed water like a duck's back.

I understand that the surface of a metalclad airship, after it has been anodically treated, is rubbed with lanolin. The lanolin is the answer. The anodic treatment gives a nicely toothed or roughened surface that makes the lanolin stick; it cannot be rubbed off. But the anodic treatment itself apparently does not have the property of shedding water as our common greases have. For years we have been using hard sticky grease, putting it on thin so that it is barely perceptible; and it works. It is a very simple thing that everybody knows and always has known. For constitutional reasons, people do not like grease; they are sure that it is dirty and that their clothes will look badly when they depart from its neighborhood.

Mr. Dix, of the Aluminum Co. of America, has developed an entirely new method. He starts with the ingot, coating it in the manufacturing process with a relatively thin amount of chemically pure aluminum, the body of the ingot being the particular alloy that affords strength. The coated ingot is forged, drawn, and worked just as the plain metal is, and retains the coating of chemically pure aluminum. I do not mean such aluminum as is sold in hardware stores, which is 99 per cent pure. This aluminum is 99.85 or 99.90 per cent pure. The pure metal has a peculiar electrolytic relation to the alloy. If it could be moved at all by the electrochemical action, the pure metal would deposit upon the alloy. As it cannot be moved, and as it does not dissolve in salt water or in any of the common natural reagents, nothing happens. This aluminum-clad sheet, or Al-clad, as it is called commercially, can be riveted without protection being provided for the rivets, because the galvanic action of the neighboring pure metal protects the rivets. Even if 0.5-in. spots are scraped off, the electrolytic action will bridge them over. It seems to me that, although it may have existed in the past, corrosion trouble need not exist any longer.

Simple Field Repairs to Metal Airplanes

MR. STOUT:—Our experience with corrosion has been similar to that of Mr. Hall. We add a little to the treatment possibly by polishing the metal, so that drops of water will roll off; a certain amount of oil, which accumulates in the polishing and rolling processes, remains. One of our airplanes operated in Florida, around Miami and Tampa, for a year and a half, under salt-water conditions, and when examined thoroughly showed no sign of corrosion anywhere. We put absolutely no finish on our airplanes. About once a week every airplane gets a complete bath, and if an airplane has been splashed with mud, the mud is carefully washed off within a couple of days, anyway. So far, we have had no corrosion trouble of any kind.

Regarding what Secretary Warner has said about repairing metal structures in the field, to repair our airplanes all you have to do is to put some sheets of duralumin of various gages, some corrugated metal, a pocketful of rivets, a hammer, a rivet-setter, and a hacksaw in the back of the car. If a hole has been punched in the side of the airplane, the bulkhead broken, or whatever it is, drive to the nearest tin-shop and bend up the section from one of the sheets of metal of the right gage on the tinner's brake, or go to the nearest Ford dealer. Then cut off the broken piece with the hacksaw and rivet the new piece in place. Every part of the airplane is made from sheet metal by machinery that can be found in almost every town of more than 1000 inhabitants in the United States.

J. OTTO SCHERER[12]:—Several Junkers monoplanes made of duralumin are operating in South America. They have been there since 1920 and have not been home for repairs yet. Mention has been made of the metalclad dirigible having a skin 0.010 in. thick. The skin on the Junkers wings near the ends is 0.012 in. and is still holding up in that salt-water operation, because the airplanes are painted. We are careful to keep them painted; painting does not cost much.

Welded Metal Returns to Cast State

C. F. NAGEL, JR.[13]:—Mr. Stout has given several reasons why duralumin and aluminum alloys are not welded for aircraft stress members. Duralumin and the high-strength aluminum alloys that are used in aircraft work are in a wrought condition and have been heat-treated. To obtain the maximum effect of heat-treatment, the metal must be in the wrought condition; the original cast state must be entirely obliterated. In welding, the material is obviously melted and, of course, all added metal is melted and then solidifies. Consequently, in the resulting weld the welding metal itself and the metal immediately adjacent to it has the structure of a casting, and so cannot be converted into the typical heat-treated state that is obtainable from a wrought metal. Likewise, such metal does not offer the maximum resistance to corrosion. Under certain conditions, a weld might be hammered and the cast structure destroyed and converted into the wrought state; but such cases are exceptional. No fillet weld can be hammered. Even though the thicker central portion of the weld might be hammered, the portion where the welded metal joins the sheet metal has only the thickness of the sheet metal, on which no hammering can be done. Moreover, these alloys in a cast state have only 2 or 3 per cent elongation in 2 in.

As regards resistance to corrosion, the experience with the Stout airplanes has raised the question whether protection of aluminum alloys is necessary, because these airplanes are not protected by any paint. Mr. Stout has explained the care with which these airplanes are handled in service. I doubt whether many airplanes receive the same care, not that such care is inadvisable, but the fact remains that they are not washed; they are in service for months at a time with little care of this kind. Even though polished duralumin offers a higher resistance to corrosion than unpolished duralumin, polished duralumin, when in constant service for months, unprotected, and without such frequent washing, may corrode, particularly in the joints where salt water can lodge and remain.

[12] Jun. S.A.E.—Chief engineer, Junkers Corporation of America, New York City.

[13] Assistant technical director, Aluminum Co. of America, Pittsburgh.

As regards the corrosion that occurs even when the airplanes have been painted, I have investigated a number of cases and have found that it may sometimes be due to the fact that the metal has not been properly heat-treated. If duralumin is not properly heat-treated, it is not so resistant to corrosion as properly heat-treated metal. Material that has been properly heat-treated also may corrode. I have seen the painting practice at a number of different plants. Many cases of corrosion can be attributed to improper methods of cleaning and painting. Paint will not adhere to metal that is not scrupulously clean. In general, not enough attention has been paid to preparing the metal for painting. I have seen vinegar used to clean the metal. Vinegar will not completely remove oil or other grease from the surface of the sheet.

Thorough Cleaning Essential to Good Painting

The first requirement for a good painting job is the use of a good cleanser that will completely remove all oil and grease. The use of solvents, such as benzol and carbon tetrachloride, is open to the objection that by their nature they build up in concentration of heavier oils which are then left on the sheet after the more volatile portions have evaporated.

A test for complete freedom from oil consists of spreading water on the metal. If the surface is oily, the water will tend to gather; if clean, the water will wet the sheet in an unbroken film. Within the last several months I have visited several aircraft plants and have applied this water test to "cleaned" material. The results were very variable. In every plant some pieces failed completely to pass this water test.

There are methods of cleaning sheet so that the product will pass the test. The caustic dip is one. This consists of immersing the object in hot 5 to 10-per cent caustic solution long enough to remove the original glossy coating. It is not difficult to control this procedure. The article is then washed in hot water to remove excess caustic, then is dipped in about a 50-per cent nitric-acid solution to neutralize the last trace of caustic, and finally is given a second clean-water rinse to remove the acid. The article should then be dried for painting. This practice also very slightly roughens the surface of the metal, thus increasing the paint adherence.

The anodic coating performs the same functions as the caustic dip and in addition provides a film which, in itself, offers resistance to corrosion. Washing the parts in hot neutral soap solutions followed by rinsing and drying also effectively cleans oily metal. The use of Deoxidene has also been recommended. This is a proprietary article primarily intended as a rust remover but it also effectively removes oil from aluminum. The article must be lightly rubbed with the chemical at full strength, and then thoroughly washed with water and dried. Certain precautions, such as the use of rubber gloves, are necessary in handling Deoxidene.

Paints and Painting Methods

The selecting of the paint itself is, of course, important. As the result of laboratory studies of various paints, it is our opinion that a bituminous paint produces very good results in places where the parts are permanently under water or are permanently moist, such as the inside of pontoons.

We believe that the use of aluminum bronze powder, of proper grade, with such paint is useful. The aluminum powder makes the paint film more impervious to water and protects the paint from the action of sunlight, so that the life of the vehicle is increased.

For such structures as the inside of wing members, which will not be wet and moist for any considerable period of time, the usual aluminum paints, spar varnish plus powder, are satisfactory.

Another item that should be given consideration is whether the individual parts constituting an assembly should receive a shop coat of paint prior to assembling, or whether the whole structure, or portions of the structure, may be first assembled and later given the first coat of paint. We all are familiar with jobs that have been almost completely assembled before the painting was begun. It is impossible to get paint into the joints after the joints have been made. All the tests and actual production structures I have ever seen have substantiated that statement. To protect the joint it is essential that the faying surfaces be painted prior to assembling. Although this is fairly well admitted, I have seen many cases in which the assembling had obviously been made without painting the joints and the joints had been painted over later. Such joints will surely corrode if subjected to corroding influences.

One other matter the aircraft industry should consider is the frequency and quality of the repairing and servicing. It is difficult to remove blistered paint, particularly around joints. If a workman is inclined merely to scrape around a joint, loosen the paint a little, brush it out, and paint over it, the repainted job may look well, but, unless all the loose paint has been completely removed, such a repainted job is worse than if no repainting has been done, as it gives a false sense of security.

Metal Plating No Protection Against Corrosion

A. M. Ney:—Has any attempt been made successfully to plate aluminum alloys with chromium?

Mr. Nagel:—Attempts have been made to plate aluminum with a number of different metals, such for example as duralumin gas-tanks with nickel. With all metal platings on aluminum, the fundamental problem of electrolytic action between the aluminum and the plating metal must be dealth with. All the common metals, with the exception of magnesium, when in metallic or electrical contact with aluminum and in the presence of moisture will result in corrosion of the aluminum. Chromium is about the least desirable of all the common metals in this respect, so chromium-plating as a means of protecting aluminum against corrosion is not worth considering.

W. Lawrence LePage[14]:—Mr. Nagel mentioned the importance of coating joints in metal construction with varnish, or whatever paint is used, before the joints are made. I recall that Ralph Upson, the originator of the metalclad airship, has shown me the thick glutinous black material that he used to protect the joints in the riveted duralumin cover. He told me that this material was put on after the joints had been made. Probably many of you recall that the joint is made on a modified sewing-machine, and wire is used instead of cotton. The black material, similar to varnish, percolates into and completely fills the joint between the surfaces of metal.

Lieutenant Harper, in presenting Commander Weyerbacher's paper, brought out the point that, in the metal

[14] Jun. S.A.E.—Assistant general manager, Pitcairn Aviation, Inc., Philadelphia.

construction work at the Naval Aircraft Factory, the main wing-spars are, for the most part, stampings, whereas the ribs of the wing are made of elongated tubing riveted with gusset-plates. Obviously, there is some reason for using one style of construction in one part of the metal structure and another form of construction in another part.

Mr. Hall has stated that, in making metal ribs, he uses stampings and forms the ribs afterward; whereas the Naval Aircraft Factory apparently uses that method in spar construction but not in rib construction. I should like to know why that procedure is adopted.

MR. HALL:—There is no particular reason for showing pictures of pressed spars and built-up ribs, because the Naval Aircraft Factory has also done the other thing. There is no reason that I should have shown pressed ribs instead of built-up work, because we also have done the other thing. The question is, which fits the particular case better?

MR. LEPAGE:—It seems to me that considerably more man-hours would be required to make a rib of riveted construction than a rib by Mr. Hall's method.

MR. STOUT:—Corrugate the metal and do without ribs.

The Nation and the Training of Teachers

AMERICA has yet to be persuaded that the training of teachers is a highly significant part of the making of the Nation. Pedagogy has been valued too much among us, scholarship too little.

Every teacher and every school-officer ought to be capable of taking part in the cooperative formulation of educational policies. School work is more highly cooperative than any other great social undertaking, even religion, even government. No one ought to enter the profession of education who is not competent to take part in responsible discussions of the general direction of educational effort.

Every teacher should be really skillful in the practice of some part or phase of the educative process. There are many forms of educational practice besides classroom instruction, but in one form or another everyone who is fit to be called a master of education should have the necessary technical skill. No doubt Americans can claim no little advancement in the mastery of educational operations; and if it may be said that we become unduly enthusiastic over special techniques, at least we have been close students of method, organization, and administrative procedures. What we have to learn from other countries is the development of our methods out of a fuller mastery of subjects and greater courage in perfecting institutions at the top which may serve as standards, models, and sources of leadership for the rest of the educational system.

American education has not put sufficient emphasis upon maturity of mind and thoroughgoing professional purpose in the training and selection of those who are to carry on the schools. There has been much talk about the low pay of teachers; and this, no doubt, has been amply justified by the facts. But, although we shall not call down upon our heads the charge of disloyalty to the profession by intimating that teachers do not deserve far greater rewards than they get, we are perfectly clear that talk about low pay should always and everywhere be accompanied by plans for more thorough professional preparation. The fact that we pay beginners in teaching relatively high salaries and accept as teachers youngsters without anything that can possibly be called an adequate preparation for an educational career, is merely an indication of our low estimate of what education can do for the individual and the Country. If we took education as seriously as we are supposed to, we should make entrance into the profession difficult, initial earnings smaller in relation to final rewards, and the paths to posts of larger responsibility longer and harder.

The fact is that America is still a frontier country so far as education is concerned. In conquering the natural resources of a vast continent rich in all material goods, we have learned to rely on mother wit, initiative, inventive genius, and individualism. The hand of fate is moving us forward to another stage wherein we shall have to place greater reliance on learning, trained capacity, and cooperation. Greatness no longer lies for us along the road of *laissez-faire*. Our conquests must be spiritual as well as material, our vision broadened and refined, or we shall court the fate which Spengler predicts for western civilization. In the development of a new and more complete and complicated command of our National destiny, education will play a far more dominating part than it has ever played before. A more serious conception of the place of the teacher in the life of the Nation is both necessary and timely.

EFFECT OF EDUCATION ON INDIVIDUAL

Let us reject, on the one hand, the view that individuality is fixed by birth, and, on the other, the view that individuality is determined by education. Let us hold that in the end we do but give the individual the materials out of which he is to make himself, granting neither to ourselves the power wholly to fix his character and the uses of his life nor to nature or to chance the power to make him what he is. We shall have some part in the process insofar as we help to place every individual clearly in the center of his own world, insofar as we put him in possession of a commanding knowledge of the issues of life, of his own powers and limitations, and of the possible consequences of his actions.

The teachers of a nation cannot become the proponents of special views, pedlars of panaceas, advocates of particular reforms. The schools are not to be taken as an arena for political warfare. Nor can we, on the other hand, exclude from our teaching the major insights of our times. Teachers are clearly called upon to be interpreters. They must speak for the present and the future as well as for the past. They must deal with their problems in the spirit of constructive statesmanship.

Teachers in general should compare favorably with any other class in the community in their understanding of world problems. Their patriotism should not be uncritical nor their devotion unreflective.

That nation in which teachers work for the most part on small mechanical tasks, under close supervision, out of textbooks, according to syllabi, is "submitting its future to the guidance of second-rate minds." The part of the teacher in the making of the Nation is not unlimited, but it is real. —Henry W. Holmes, dean of Harvard Graduate School of Education.

Symposium on Volatility and Detonation

At the Research Session of the 1928 Annual Meeting held Jan. 26, four papers were presented which dealt with the subjects of volatility and knock characteristics of fuels. The first paper, on Volatility Data from Gasoline Distillation Curves, was presented by Oscar C. Bridgeman, of the Bureau of Standards. It presented a recent analysis of data obtained by the equilibrium-distillation method for a variety of gasolines, together with a comparison of these data with the distillation curves of these fuels as determined by the procedure of the American Society for Testing Materials.

In a paper on Results of Two Detonation Surveys, H. K. Cummings, of the Bureau of Standards, outlined a survey made of the relative detonation characteristics of available fuels as determined by the routine method of fuel testing now employed by the Bureau.

A paper on Comparison of Methods of Measuring Knock Characteristics of Fuels, by Dr. Graham Edgar, of the Ethyl Gasoline Corporation, compared the results obtained on five selected motor fuels by nine laboratories employing different methods, and points out two distinct problems involved in the rating of the fuels as indicated by the data.

In a paper on Methods of Measuring Detonation, Neil MacCoull, of The Texas Co., described an investigation of the possibilities of correlating measurements of the antiknock values of six different gasolines as determined by various laboratories.

Excepting Dr. Edgar's paper, which was printed in full in THE JOURNAL for January, 1928, beginning on p. 41, the papers mentioned are printed herewith, together with an abstract of each preceding the text of the paper.

Volatility Data from Gasoline Distillation Curves[1]

By Oscar C. Bridgeman[2]

FIRST referring to previous reports made on laboratory methods for measurement of volatility, the author states that data for a variety of gasolines, obtained by the equilibrium air-distillation method, have been analyzed recently in comparison with the distillation curves of these fuels as determined by the procedure practised by the American Society for Testing Materials. According to the author, this analysis appears to indicate a definite relationship between the results on volatility and those obtained by the standard A.S.T.M. distillation method, so that it seems possible to deduce from the latter with reasonable accuracy the information on volatility which is pertinent to satisfactory engine performance. It is stated also that volatility can be regarded as the tendency to escape into the vapor or gaseous state and this escaping tendency is determined by factors which must be precisely specified so that numerical values for volatility may have significance. Throughout the paper, the expression "air-fuel mixture" is used to indicate a mixture of air and gasoline supplied, while the term "air-vapor mixture" is applied to the resultant mixture of air and vapor formed when all or part of the liquid changes to vapor in the presence of air.

After stating that all the data on volatility were obtained with the Sligh equilibrium air-distillation apparatus, the author comments upon this equipment and describes its calibration, the method of using the equilibrium air-distillation apparatus, and the calculation of results. The experimental data are then analyzed. A chart for the estimation of volatility from the A.S.T.M. distillation curves is explained, and is used in testing the general correlation of results. In conclusion, it is said that the A.S.T.M. distillation curves give a true indication of the relative volatilities of gasolines.

Appendix 1 presents notes on fuel requirements for engine starting. Appendix 2 contains recomputed values for the lean explosive limits of gasolines.

THE satisfactory performance of internal-combustion engines is largely dependent upon fuel characteristics and definite knowledge of the nature of this dependence is of great importance. Since 1922, the Bureau of Standards has been cooperating with the automotive and petroleum industries in a general study of the various phases of this problem. One of the more important characteristics of a fuel is its volatility and several reports[3] have been made on laboratory methods for the measurement of this property, special emphasis having been placed on the equilibrium air-distillation method. Data for a variety of gasolines, obtained by this latter method, have recently been analyzed in comparison with the distillation curves of these fuels obtained by the procedure practised by the American Society for Testing Materials. This analysis appears to indicate a definite general relationship between the results on volatility and those obtained by the standard A.S.T.M. distillation method, so that it seems possi-

[1] Published by permission of the Director of the Bureau of Standards, City of Washington.

[2] Research associate, Bureau of Standards, City of Washington.

[3] See THE JOURNAL, April, 1926, p. 393, and August, 1926, p. 151, by T. S. Sligh, Jr.; see also THE JOURNAL, July, 1927, p. 15, by D. C. Ritchie.

ble to deduce from the latter with reasonable accuracy all the information on volatility which is pertinent to satisfactory engine performance.

Volatility may be regarded as the tendency to escape into the vapor or gaseous state, and this escaping tendency is determined by a number of factors which must be specified precisely in order that numerical values for volatility may have significance. Of the various possible methods of defining volatility, the most convenient, for purposes of the present report, is to specify the temperature at which a given air-vapor mixture will be formed under equilibrium conditions at a pressure of one atmosphere from any mixture of liquid fuel and air supplied when a given percentage is evaporated. According to this definition, one gasoline will be more volatile than another if it forms the given air-vapor mixture at a lower temperature, for the same percentage evaporated. To obtain complete information, it is necessary to vary the amount of air present for given weights of fuel and to employ various temperatures.

This report presents all the volatility measurements of the foregoing type which have been made at the Bureau of Standards over a sufficiently extensive range of mixtures and temperatures. The expression "air-fuel mixture" is used throughout to indicate a mixture of air and liquid gasoline supplied, while the term "air-vapor mixture" is applied to the resultant mixture of air and vapor formed when all or part of the liquid changes to vapor in the presence of air.

Description of Apparatus

All the data on volatility were obtained with the Sligh equilibrium air-distillation apparatus which has been previously described[1], a scale drawing of which is shown in Fig. 1. The essential part of the apparatus is the vaporization coil *a* which is constructed of copper tubing of 7/16-in. outside diameter 16 ft. long, bent into

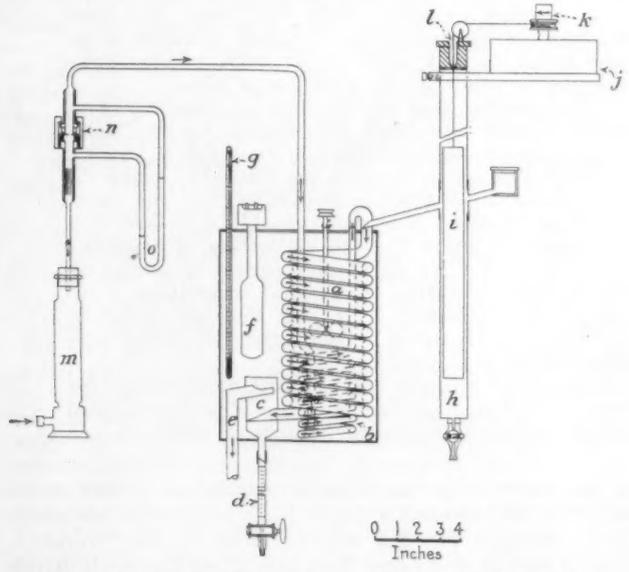


Fig. 1—Sligh Apparatus for Equlibrium Air-Distillation

the form of a helix. Liquid gasoline and air in definite proportions are supplied at uniform rates and the liquid remaining after passage through the coil is collected and measured. This coil is immersed in a stirred bath containing water, the temperature of which is regulated by the heater *f* above room temperature and by the addition of ice below room temperature.

The flow of gasoline is controlled by displacement from the reservoir *h* by the hollow plunger *i* which is operated by clockwork. Partial stoppage of the overflow tube into *a* is avoided by providing an offset in the reservoir wall at this point. The plunger is suspended by a fine nichrome wire, 0.008 in. in diameter, which passes through a packing gland *l* at the top of the reservoir and thence over an idler pulley to connect to a drum *k* mounted on the spindle of the clock *j*. The packing gland consists of a thin piece of leather pierced by a very fine hole for the wire and mounted between two metal discs which serve to compress the leather and force it tightly around the wire. A recess is provided at the top which can be filled with mercury to assure absence of leakage. The mainspring was removed from the clock, which is driven by the weight of the plunger acting through the drum mounted on the main shaft. The gear train and escapement serve to regulate the motion and to maintain a constant rate of fall of the plunger. To permit rewinding, a ratchet clutch is placed on the top of the clock and engages a gear on the drum. Four drums are available with the present apparatus, permitting variations in the rate of feed from 1 to 4 ml. per min. (1 ml. = 1 milliliter = 1.000027 cc.).

The air, obtained from the low-pressure laboratory system, is dried by passage through a tower *m* containing calcium chloride, and is forced through a calibrated-orifice meter *n*. To reduce turbulence on the high-pressure side of the orifice, a number of tubes are placed lengthwise in the air passage as shown in Fig. 1. The water manometer *o* is used to indicate the pressure-drop across the orifice. Five different orifices were used, which allowed considerable variation in the amounts of air supplied. After passage through the flowmeter, the air is led to the bottom of the coil *b* so that it can be preheated or precooled to the temperature of the bath before coming into contact with the gasoline.

At the bottom of the vaporization helix *a*, the mixture flows into a separating chamber *c* where the velocity is reduced. The air-vapor mixture passes out through the exhaust pipe *e* while the residual liquid drains down into the burette *d*, where it is measured.

Calibration of Apparatus

The volume of gasoline supplied to the vaporization coil is dependent upon the displacement of the plunger, the size of the drum on the clock spindle and the clock rate. The plunger has an outside diameter of 1.000 in. so that its displacement is 5.068 ml. per cm. immersion. The clock rate was found to depend upon the torque, beyond certain limits, and a number of determinations of the rate were made using a wide range of weights for each drum, the time required for one complete revolution being measured by means of a calibrated stopwatch. These data are shown in graphical form in Fig. 2, in which the time per revolution is plotted against the torque. Over a considerable range, the curve is essentially flat and the clock rate is constant, but the departure from constancy is very marked toward each end of the curve.

Appropriate weights for each drum were computed from values read from the curve so as to have the same clock rate in all cases, namely, one revolution in 14.95

[1] See The Journal, August, 1926, p. 151.

min. In doing this, allowance was made for the fact that the torque decreases during an actual volatility experiment due to increasing loss of weight with depth of immersion. Adjustment of the weight of the plunger was readily accomplished by means of lead shot put into

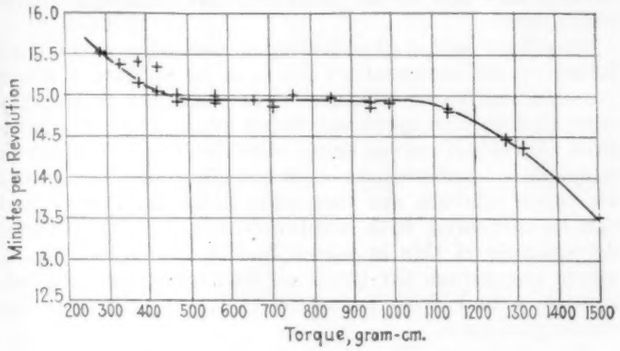


FIG. 2—DETERMINATION OF THE CLOCK RATE

The Clock Rate Was Found To Depend upon the Torque beyond Certain Limits. The Curve Resulting from Plotting Time Per Revolution Against Torque Is Essentially Flat over a Considerable Range and the Clock Rate Is Constant, but the Departure from Constancy Is Very Marked toward Each End

or withdrawn from the interior of the plunger. The diameters of the drums and of the wire were measured by means of micrometer calipers, the effective diameters of the drums being taken as the actual values plus that of the wire. The volume of gasoline displaced per unit of time, expressed in milliliters per minute, is

$$F=2.54\,\eta\,ADr \qquad (1)$$

where A is the displacement per centimeter of length of the plunger, D is the effective diameter in inches, and r is the clock rate in revolutions per minute. The constants for the four drums are given in Table 1.

TABLE 1—CONSTANTS OF THE DRUMS ON THE CLOCK SPINDLE

No.	Effective Diameter, In.	Milliliters Per Revolution	Milliliters Per Min.
1	0.371	15.00	1.003
2	0.742	30.00	2.006
3	1.113	45.00	3.010
4	1.484	60.00	4.013

The calibration of the orifices used in the flowmeter was effected by comparison with a master orifice, the constant of which was accurately obtained by means of a standard flowmeter. The five orifices used in this work had diameters of approximately 1/16, 3/32, 1/8, 5/32, and 3/16 in. The rate of air flow in grams per minute is given by the formula

$$W=K\sqrt{H\rho} \qquad (2)$$

where K is the constant for the particular orifice, H is the difference in level in centimeters of the meter in the two arms of the manometer, and ρ is the density of the air at the temperature and pressure on the low-pressure side of the orifice. If the temperature and pressure are fairly constant, $K\sqrt{\rho}$ can be designated by k and can be considered constant for a particular orifice. Relation (2) then becomes:

$$W=k\sqrt{H} \qquad (3)$$

Multiplication of F in relation (1) by d, the specific gravity of the gasoline at the temperature of the room, to transform into grams per minute, and combination of this equation with relation (2), permits a direct calculation of the head of water H in the manometer to give any desired air-fuel mixture for a specific rate of gasoline feed. This formula is

$$H=(MFd/k)^2 \qquad (4)$$

where M is the desired air-fuel mixture.

MAGNITUDE OF DEPARTURE FROM EQUILIBRIUM

In any dynamic system the question of the attainment of equilibrium is a serious one and a number of tests were made with the present apparatus to determine the magnitude of the departure from equilibrium. Experiments were conducted with several gasolines and with toluene, at two temperatures and with various air-fuel mixtures, using the four different rates of feed for each temperature and supplied mixture. In all cases it was found that the results indicated a small progressive increase in the percentage evaporated with decrease in the rate of feed with each constant temperature and mixture and with each fuel. Since the rate of feed varied from 4 to 1 ml. per min., it was possible to extrapolate to zero rate of feed, and hence to obtain the value for equilibrium between the liquid gasoline and its vapor. Correlation of these data at the two temperatures and with the various air-fuel mixtures led to the general relation for the equilibrium percentages evaporated in terms of the measured values; namely,

$$P=P_0(1+0.0125F) \qquad (5)$$

where P_0 is the experimentally determined percentage evaporated for a given feed F. The correction appears to be independent of the temperature, the air-fuel mixture and the particular fuel used. For a feed of 2 ml. per min., an experimental value of 97.5 per cent evaporated would correspond to an equilibrium value of 100 per cent, which is almost identical in magnitude with the departure from equilibrium recently pointed out by Stevenson and Babor[5]. Verification of the conclusion that the experimental results, thus corrected, represent equilibrium conditions was obtained by experimentation on toluene. In this case, the known molecular weight and vapor-pressure curve permit a computation of the theoretical values of the volatility.

Determinations were made with a considerable number of air-toluene mixtures and at four temperatures, namely, at 0, 15, 25 and 35 deg. cent. (32, 59, 77 and 95 deg. fahr.). The temperatures corresponding to four resultant air-vapor mixtures covering the range of interest were obtained from the plot of these experimental data and are compared in Table 2 with the calculated temperatures. This agreement makes it apparent that, within the experimental error of the measurements, the corrected results obtained with this apparatus closely approximate equilibrium conditions.

TABLE 2—COMPARISON OF OBSERVED AND CALCULATED TEMPERATURES OF VARIOUS RESULTANT AIR-VAPOR MIXTURES FOR TOLUENE

Mixture	Temperatures Observed Deg. Cent.	Observed Deg. Fahr.	Calculated Deg. Cent.	Calculated Deg. Fahr.
8 to 1	23	73	25	77
12 to 1	17	63	17	63
16 to 1	12	54	12	54
20 to 1	8	46	8	46

The method of using the equilibrium air-distillation apparatus is comparatively simple. In making an experiment, the drum on the clock spindle was rotated so as to raise the plunger to the top of the reservoir, which

[5] See *Industrial and Engineering Chemistry*, December, 1927, p. 1361.

was then filled with the gasoline. For most purposes, the 2 or 3-ml. per min. drums were found to be the most convenient. The temperature of the bath was adjusted and the manometer reading for the desired air-fuel mixture was calculated from equation (4). The air supply was turned on, the manometer head was adjusted to the computed value and the clock was started. A few minutes were allowed for constancy to be attained and measurements were then made of the amount unvaporized.

In determining the volume collected, two different sizes of burettes were found to be convenient. For small amounts evaporated, the volume collected per unit of time was large and a burette of 5-ml. capacity was used; whereas, for large amounts evaporated, one of 1-ml. capacity was employed. Drainage errors in the burette were avoided by starting a stop-watch when the liquid passed a given mark, draining into a calibrated flask of 1 or 5-ml. capacity and stopping the watch when the meniscus passed the mark a second time. The accuracy of the stop-watch was checked periodically.

To express the experimental results on a weight basis, it is necessary to know the specific gravities of the original fuel and of the residual liquid after partial vaporization. A determination of the latter is necessary for each experiment on account of the change in composition of the liquid as evaporation progresses, which is different at every temperature even for the same percentage evaporated. The specific gravities of the samples were measured at any convenient known temperature and were transformed to other temperatures by means of the National Standard Petroleum Oil Tables[6]. The percentage evaporated by weight is given by the relation

$$P = [(Fd_1 - Vd_2)/Fd_1]\,100 \qquad (6)$$

where F is the volume of liquid in milliliters supplied per minute, computed from equation (1), d_1 is the specific gravity of the original gasoline at room temperature, V is the volume of the liquid residue collected per minute, and d_2 is the specific gravity of the residue at the temperature of the bath containing the vaporization coil. It has been found that the small difference in temperature between the residue collected in the burette and that in the bath does not introduce appreciable error.

To obtain values of volatility as defined previously in terms of the temperature required to produce a given resultant air-vapor mixture, it is necessary to plot the corrected percentages evaporated against the temperature, individual curves being obtained for each mixture supplied. Temperatures corresponding to any desired air-vapor mixture are then read from the curves and can be compared with similar results for other fuels. An example of this is shown in Fig. 3 for fuel No. 1, where the curves for three air-fuel mixtures supplied, namely, 4 to 1, 8 to 1, and 15 to 1, are shown by the continuous lines.

The circles in Fig. 3 represent the experimentally observed values corrected to equilibrium by equation (5). The dotted lines indicate resultant air-vapor mixtures of 12 to 1, 16 to 1 and 20 to 1. At 75 per cent evaporated from a 15 to 1 mixture supplied, it is obvious that the air-vapor mixture will have a composition of 20 to 1. The same composition is obtained from an 8 to 1 mixture at 40 per cent evaporated, and from a 4 to 1 mixture at 20 per cent evaporated. By drawing a smooth curve through these points of equal composition, it is possible to determine the temperature at any percentage evaporated which will produce this constant air-vapor mixture. Thus, at 75 per cent, a temperature of 46 deg. cent. (115 deg. fahr.) is required to produce a 20 to 1 air-vapor mixture. At temperatures below this, leaner mixtures are formed; at higher temperatures, the mixtures are richer.

All the data given in this report apply to saturated air-vapor mixtures at a pressure of one atmosphere, so that, under these conditions, a specification of the percentage evaporated for any given fuel is sufficient to define uniquely the temperature corresponding to a particular resultant mixture. At any given percentage evaporated to form a specific air-vapor mixture, the volatilities of different gasolines are indicated by these temperatures, a higher volatility corresponding to a lower temperature. At different percentages evaporated, the order of the volatilities for different samples may vary, so that, in general, it is advisable to consider a wide range of percentages.

[6] See Bureau of Standards Circular No. 154, 1924.

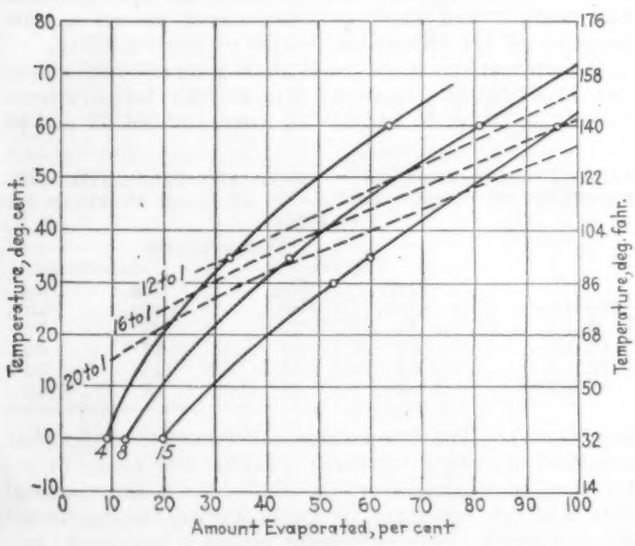


FIG. 3—VOLATILITY-TEMPERATURE CURVES

To Obtain Values of Volatility in Terms of the Temperature Required To Produce a Given Resultant Air-Vapor Mixture, It is Necessary To Plot the Corrected Percentages Evaporated Against the Temperature, Individual Curves Being Obtained for Each Mixture Supplied. Temperatures Corresponding to Any Desired Air-Vapor Mixture Are Then Read from the Curves and Can Be Compared with Similar Results for Other Fuels

EXPERIMENTAL DATA

Data on 15 gasolines were obtained at atmospheric pressure over a considerable range of temperatures and of supplied mixtures. Some less extensive measurements have been made on a number of other samples, but the data are not sufficiently complete to permit a general analysis. Specification data for the 15 samples are given in Table 3.

Fuels 1, 3, 1*A*, 2*A*, 3*A* and 4*A* were furnished by the Atlantic Refining Co. for the work on engine starting and showed considerable differences in their A.S.T.M. distillation curves over the initial range. Fuel *A* was a sample of U. S. Motor gasoline, fuel *B* was a domestic aviation gasoline, while fuel *C* was a 50-50 mixture of fuels *A* and *B*. Fuels *D*, *E* and *F* were special blends furnished by The Texas Co. and had the same temperatures at the 20-per cent and the 90-per cent points but differed widely at the 50-per cent point. Fuel *RH* was

TABLE 3—SPECIFICATION DATA FOR FUELS USED IN VOLATILITY WORK

Fuel Sample No.	Distillation Temperatures: Initial Boiling-Point Deg. Cent.	Initial Boiling-Point Deg. Fahr.[7]	20 Per Cent Deg. Cent.	20 Per Cent Deg. Fahr.[7]	50 Per Cent Deg. Cent.	50 Per Cent Deg. Fahr.[7]	90 Per Cent Deg. Cent.	90 Per Cent Deg. Fahr.[7]	End-Point Deg. Cent.	End-Point Deg. Fahr.[7]	60 Deg./60 Deg. Specific Gravity	Loss, Per Cent	Residue, Per Cent
1	89	192	127	261	156	313	202	396	223	433	0.764	1.3	1.7
3	59	138	121	250	159	318	199	390	222	432	0.755	1.8	1.2
1A	50	122	104	219	141	286	202	396	226	439	0.733	2.3	1.7
2A	53	127	106	223	141	286	198	388	225	437	0.739	1.5	1.5
3A	58	136	110	230	141	286	196	385	218	424	0.738	1.0	2.0
4A	55	131	112	234	141	286	189	372	215	419	0.731	1.5	1.5
A	38	100	100	212	136	277	199	390	220	428	0.768	1.2	1.3
B	32	90	80	176	102	216	136	277	155	311	0.714	2.0	1.0
C	36	97	87	189	116	241	178	352	215	419	0.741	1.2	1.3
D	48	118	103	217	122	252	204	399	227	441	0.754	0.8	1.2
E	47	117	103	217	138	280	201	394	222	432	0.762	0.7	1.8
F	43	109	103	217	164	327	199	390	223	433	0.766	1.0	1.0
RH	51	124	99	210	126	259	169	336	204	398	0.739	0.5	1.1
L	112	234	118	244	126	259	152	306	180	356	0.751	0.3	1.2
RPC	38	100	88	190	135	275	200	392	222	432	0.747	1.0	1.5

[7] Approximate.

a Russian heavy naphtha furnished by the Vacuum Oil Co. Fuel *L* was a special blend furnished by the Standard Oil Co. of New Jersey for work on crankcase dilution. Fuel *RPC* was a Dubbs-process cracked-gasoline from a Mid-Continent topped crude oil supplied by the Universal Oil Products Co.

From Table 3 it is seen that the A.S.T.M. distillation curves of these samples cover a considerable range of temperatures. At 20 per cent evaporated, the temperatures range from 80 to 127 deg. cent. (176 to 261 deg. fahr.); at 50 per cent, from 102 to 164 deg. cent. (216 to 327 deg. fahr.); and at 90 per cent, from 136 to 204 deg. cent. (277 to 399 deg. fahr.). The first 12 of these gasolines were used in a general analysis of the volatility, while the last three were employed to test the validity of the relations obtained from this analysis.

The volatility results for these 12 gasolines obtained with the equilibrium-air distillation apparatus are shown in Table 4. In accord with the definition of volatility adopted in this report, the temperatures in degrees centigrade corresponding to resultant mixtures of 12 to 1, 16 to 1 and 20 to 1 are listed for every 10 per cent evaporated from 10 to 90 per cent, inclusive. These data were obtained from the experimental measurements in the manner described previously in connection with Fig. 3. Intercomparison of the temperatures for different fuels, corresponding to the same percentage evaporated and resultant air-vapor mixture, serves to place the gasolines in the order of their volatilities under these conditions. Under other conditions, the order may be changed. Thus, the order of the volatilities for the last three fuels having a 20 to 1 resultant mixture in Table 4 is *F*, *E*, *D* for 10 per cent evaporated, and is *D*, *E*, *F* for 30 per cent evaporated.

TABLE 4—TEMPERATURES OF RESULTANT AIR-VAPOR MIXTURES, DEG. CENT.[8]

Fuel Sample No.	Per Cent: 10	20	30	40	50	60	70	80	90
					20 *to* 1 *Mixture*				
1	15 (59.0)	21.5 (70.7)	27 (80.6)	32 (89.6)	36 (96.8)	40 (104.0)	44 (111.2)	48 (118.4)	52 (125.6)
3	.. (....)	21 (69.8)	26 (78.8)	31 (87.8)	35 (95.0)	39 (102.2)	42 (107.6)	46 (114.8)	49 (120.2)
1A	—7 (19.4)	2 (35.6)	9 (48.2)	15.5 (59.9)	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)
2A	—2.5 (27.5)	5 (41.0)	11 (51.8)	15.5 (59.9)	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)
3A	1 (33.8)	6 (42.8)	10.5 (50.9)	14 (57.2)	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)
4A	0 (32.0)	7.5 (45.5)	13 (55.4)	17.5 (63.5)	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)
A	.. (....)	.. (....)	7 (44.6)	13 (55.4)	19 (66.2)	26 (78.8)	33 (91.4)	39.5 (103.1)	46 (114.8)
B	.. (....)	.. (....)	.. (....)	—5 (23.0)	—3 (26.6)	—1 (30.2)	0 (32.0)	1 (33.8)	1 (33.8)
C	.. (....)	.. (....)	.. (....)	2.5 (36.5)	8 (46.4)	13.5 (56.3)	19 (66.2)	24.5 (76.1)	30 (86.0)
D	2 (35.6)	3 (37.4)	5 (41.0)	7.5 (45.5)	10.5 (50.9)	14.5 (58.1)	20.5 (68.9)	30 (86.0)	41.5 (106.7)
E	—3 (26.6)	5.5 (41.9)	11.5 (52.7)	17.5 (63.5)	23.5 (74.3)	29.5 (85.1)	35.5 (95.9)	41 (105.8)	47 (116.6)
F	—13 (8.6)	4 (39.2)	19 (66.2)	31 (87.8)	40 (104.0)	46 (114.8)	49.5 (121.1)	51.5 (124.7)	53 (127.4)
					16 *to* 1 *Mixture*				
1	.. (....)	25 (77.0)	30 (86.0)	35 (95.0)	39.5 (103.1)	44 (111.2)	48 (118.4)	52.5 (126.5)	57 (134.6)
3	.. (....)	24 (75.2)	30 (86.0)	35 (95.0)	39.5 (103.1)	43.5 (110.3)	47 (116.6)	51 (123.8)	54 (129.2)
1A	—5 (23.0)	5 (41.0)	13 (55.4)	19 (66.2)	25.5 (77.9)	.. (....)	.. (....)	.. (....)	.. (....)
2A	2 (35.6)	9.5 (49.1)	15.5 (59.9)	21 (69.8)	25.5 (77.9)	.. (....)	.. (....)	.. (....)	.. (....)
3A	5 (41.0)	11 (51.8)	15.5 (59.9)	20 (68.0)	24 (75.2)	.. (....)	.. (....)	.. (....)	.. (....)
4A	4 (39.2)	11 (51.8)	17 (62.6)	21.5 (70.7)	25.5 (77.9)	.. (....)	.. (....)	.. (....)	.. (....)
A	.. (....)	.. (....)	.. (....)	15 (59.0)	22 (71.6)	29 (84.2)	36 (96.8)	43 (109.4)	50 (122.0)
B	.. (....)	.. (....)	.. (....)	.. (....)	1 (33.8)	4 (39.2)	6.5 (43.7)	8 (46.4)	10 (50.0)
C	.. (....)	.. (....)	.. (....)	.. (....)	9.5 (49.1)	16 (60.8)	22.5 (72.5)	29 (84.2)	35.5 (95.9)
D	8.5 (47.3)	9 (48.2)	10 (50.0)	11 (51.8)	14 (57.2)	18 (64.4)	25 (77.0)	34 (93.2)	46 (114.8)
E	3 (37.4)	9.5 (49.1)	15 (59.0)	21.5 (70.7)	27 (80.6)	33.5 (92.3)	39.5 (103.1)	45.5 (113.9)	51.5 (124.7)
F	—5 (23.0)	12 (53.6)	26 (78.8)	36.5 (97.7)	45 (113.0)	51 (123.8)	54 (129.2)	56 (132.8)	57.5 (135.5)
					12 *to* 1 *Mixture*				
1	.. (....)	29.5 (85.1)	34 (93.2)	39 (102.2)	43 (109.4)	48 (118.4)	52.5 (126.5)	57 (134.6)	61.5 (142.7)
3	.. (....)	.. (....)	34.5 (94.1)	40 (104.0)	44.5 (112.1)	48.5 (119.3)	52.5 (126.5)	56 (132.8)	60 (140.0)
1A	—2 (28.4)	9 (48.2)	17 (62.6)	23.5 (74.3)	30 (86.0)	36 (96.8)	.. (....)	.. (....)	.. (....)
2A	6.5 (43.7)	14.5 (58.1)	21 (69.8)	27 (80.6)	32 (89.6)	37 (98.6)	.. (....)	.. (....)	.. (....)
3A	8.5 (47.3)	15 (59.0)	20.5 (68.9)	25.5 (77.9)	30.5 (86.9)	35 (95.0)	.. (....)	.. (....)	.. (....)
4A	7.5 (45.5)	15.5 (59.9)	21.5 (70.7)	26 (78.8)	30.5 (86.9)	34 (93.2)	.. (....)	.. (....)	.. (....)
A	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)	32 (89.6)	39 (102.2)	46 (114.8)	53.5 (128.3)
B	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)	7 (44.6)	11 (51.8)	14.5 (58.1)	18 (64.4)
C	.. (....)	.. (....)	.. (....)	.. (....)	.. (....)	18 (64.4)	25 (77.0)	32.5 (90.5)	40 (104.0)
D	15 (59.0)	15.5 (59.9)	16 (60.8)	17.5 (63.5)	19.5 (67.1)	23.5 (74.3)	30 (86.0)	39 (102.2)	51.5 (124.7)
E	8 (46.4)	14 (57.2)	20 (68.0)	26 (78.8)	32 (89.6)	38 (100.4)	44 (111.2)	50 (122.0)	56 (132.8)
F	2 (35.6)	18 (64.4)	31 (87.8)	42 (107.6)	50.5 (122.9)	55.5 (131.9)	59 (138.2)	61 (141.8)	62.5 (144.5)

[8] Approximate fahrenheit equivalents are stated in parentheses.

Correlation of Results

Although the equilibrium air-distillation apparatus seems to be satisfactory as a standard, nevertheless it is not convenient for testing a large number of gasolines rapidly, due to the time required to obtain complete information on each sample. Since the A.S.T.M. distillation test is simple, reproducible and in common use, the interpretation of the curves obtained from it in terms of volatility data would permit the continuation of its use as an accepted test and the computation of volatility from it directly. A scheme of correlation of the results obtained by these two methods is suggested by the Clapeyron equation, which is

$$\frac{dp}{dT} = \frac{L}{T(V_1 - V_2)} \qquad (7)$$

where p is the vapor pressure at the temperature T in degrees centigrade, absolute; L is the latent heat of vaporization per mol; V_1 is the volume of the vapor per mol; and V_2 is the volume of the liquid per mol. In general, V_2 is small in comparison with V_1; so, it can be neglected. Assuming that the vapor obeys the perfect gas law, namely, $pV = RT$, where R is the bas constant per mol, the Clapeyron equation can be written in the approximate form

$$\frac{1}{p}\cdot\frac{dp}{dT}=\frac{L}{RT^2} \tag{8}$$

Integration yields the relation

$$\log\frac{p}{760}=\frac{L}{RT_B}\left(1-\frac{T_B}{T}\right)=a\left(1-\frac{T_B}{T}\right) \tag{9}$$

where L is assumed to be independent of temperature, and T_B is the boiling-point corresponding to a pressure of 760 mm. Experimental evidence has shown that L/RT_B is a constant for substances like the hydrocarbons, which have similar properties, so that it can be replaced by the symbol a. Hence for a given value of p, the ratio T_B/T will be constant.

$$T_B/T=b \tag{10}$$

For other values of p, the constant b will be different. It seems very probable that such a relation would hold for mixtures of hydrocarbons such as gasolines.

Since the equilibrium air-distillation results are expressed on a weight basis, the partial pressure of the gasoline vapor is dependent upon the molecular weight of the vapor, which will change with evaporation. At any given percentage evaporated, the molecular weights of the vapors from different gasolines in a specific air-vapor mixture should not be greatly different, and hence their partial pressures would be roughly the same. In the A.S.T.M. distillation test, the vapor is at a constant pressure of one atmosphere and hence fulfills the desired conditions in this respect. But the temperature of the liquid is considerably higher than that of the vapor, and a strict application of equation (10) implies that the two temperatures be identical. If the difference in temperature at a given percentage evaporated is approximately constant for all normal gasolines, a rule analogous to that given in equation (10) for pure substances should be roughly applicable to the present case. If, as seems probable, the variations in partial pressures in a particular air-vapor mixture of different gasolines, obtained with the equilibrium air-distillation apparatus, are compensated by corresponding variations in temperature between the liquid and vapor in the A.S.T.M. distillations for the same percentage evaporated, then such a rule should hold very closely. In this case, the constant would vary with the percentage evaporated in a regular manner.

Comparison of Ratios

Some verification of this prediction has been obtained in two cases. Cragoe and Eisinger[9] found that the ratio of the absolute temperature from the A.S.T.M. distillation curve at 5 per cent evaporated to the absolute temperature of a 20 to 1 resultant air-vapor mixture at 5 per cent evaporated was a constant independent of the gasoline, and the same was true at 15 per cent evaporated to form a 13.3 to 1 mixture. Accordingly, a comparison of the absolute-temperature ratios from the A.S.T.M. distillation curves and the equilibrium air-distillation results seemed worthwhile, over the whole range of percentages evaporated and for a number of resultant mixtures.

[9] See THE JOURNAL, March, 1927, p. 353.

TABLE 5—A.S.T.M. DISTILLATION TEMPERATURES IN DEGREES CENTIGRADE[10] CORRECTED FOR LOSS

Fuel Sample No.	Per Cent 5	10	20	30	40	50	60	70	80	90	95
1	107 (225)	114 (237)	126 (259)	136 (277)	146 (295)	155 (311)	164 (327)	173 (343)	183 (361)	199 (390)	212 (414)
3	74 (165)	91 (196)	118 (244)	137 (279)	149 (300)	158 (316)	166 (331)	174 (345)	183 (361)	197 (387)	210 (410)
1A	66 (151)	80 (176)	100 (212)	114 (237)	127 (261)	139 (282)	150 (302)	161 (322)	175 (347)	195 (383)	212 (414)
2A	72 (162)	84 (183)	104 (219)	117 (243)	128 (262)	139 (282)	150 (302)	162 (324)	175 (347)	195 (383)	211 (412)
3A	81 (178)	93 (199)	109 (228)	120 (248)	130 (266)	140 (284)	151 (304)	162 (324)	175 (347)	193 (379)	208 (406)
4A	77 (171)	90 (194)	110 (230)	122 (252)	132 (270)	140 (284)	150 (302)	160 (320)	171 (340)	186 (367)	200 (392)
A	58 (136)	75 (167)	97 (207)	112 (234)	124 (255)	135 (275)	147 (297)	161 (322)	176 (349)	196 (385)	209 (408)
B	51 (124)	63 (145)	78 (172)	87 (189)	94 (201)	101 (214)	107 (225)	113 (235)	120 (248)	132 (270)	142 (288)
C	56 (133)	69 (156)	86 (187)	97 (207)	106 (223)	115 (239)	124 (255)	135 (275)	151 (304)	174 (345)	192 (378)
D	77 (171)	89 (192)	102 (216)	110 (230)	116 (241)	122 (252)	127 (261)	135 (275)	151 (304)	200 (392)	220 (428)
E	69 (156)	84 (183)	102 (216)	116 (241)	127 (261)	137 (279)	148 (298)	162 (324)	179 (354)	199 (390)	212 (414)
F	57 (135)	72 (162)	101 (214)	127 (261)	148 (298)	163 (325)	173 (343)	179 (354)	185 (365)	198 (388)	210 (410)
RH	75 (167)	85 (185)	99 (210)	109 (228)	118 (244)	126 (259)	134 (273)	143 (289)	153 (307)	168 (334)	182 (360)
L	116 (241)	117 (243)	118 (244)	120 (248)	123 (253)	126 (259)	130 (266)	134 (273)	141 (286)	152 (306)	163 (325)
RPC	54 (129)	66 (151)	86 (187)	104 (219)	119 (246)	134 (273)	147 (297)	162 (324)	180 (356)	198 (388)	210 (410)

[10] Approximate fahrenheit equivalents are stated in parentheses.

For this comparison, the A.S.T.M. distillation data were corrected for loss and temperatures were read from the corrected curves at a number of percentages evaporated, which are given in Table 5. This loss is the difference between the volume originally taken and the sum of that collected in the receiver and that remaining in the flask at the end of the distillation. The assumption was made that all this loss occurred before the first drop came over, and the procedure adopted in applying this correction simply amounted to a displacement of the distillation curve toward the right by an amount equal to the loss. The values of the loss for each of the fuels used are given in the next to the last column of Table 3. Since the method used in the equilibrium air-distillation apparatus precludes any loss, it was felt that the comparison with the A.S.T.M. distillation results would be more logical if these were corrected for the loss.

One difference between the results of the two methods of distillation should be pointed out. The percentages recorded in the A.S.T.M. distillation curves represent the volume collected per 100 ml. of original sample, while, in the equilibrium air-distillation method, the percentages are expressed as so many grams per 100 grams of original sample. The difference between the two types of percentage is appreciable but not very large, and a correction to a common basis could be made if the density of the distillate in the A.S.T.M. test were determined for a number of percentages evaporated. Since this requires additional experimentation and since each of the two types of percentage are in extensive use, the comparison was made in a somewhat illogical manner using the accepted variables, thereby permitting an interpretation of the A.S.T.M. distillation curves directly in terms of the temperatures corresponding to various air-vapor mixtures.

A general study of the relation between the temperatures on the A.S.T.M. and the equilibrium air-distillation curves for the same percentages evaporated indicated that the ratios of the absolute temperatures

were constant and independent of the fuel for any given air-vapor mixture and percentage evaporated. These ratios are given in Table 6 at every 10 per cent and for the three mixtures 12 to 1, 16 to 1 and 20 to 1. The numerical value of the ratio for a constant mixture increases with the percentage evaporated, and for a constant percentage it decreases with the richness of the mixture. The averages of the ratios for these three mixtures are shown in Table 7, and at any percentage evaporated the temperature ratio for the 16 to 1 mixture is very close to the mean of the ratios for the 20 to 1 and the 12 to 1 mixtures, differing from them by 0.02 on the average.

TABLE 6—RATIO OF A.S.T.M. TO EQUILIBRIUM AIR-DISTILLATION TEMPERATURES[11]

Fuel Sample No.	Per Cent 10	20	30	40	50	60	70	80	90
20 to 1 Resultant Air-Vapor Mixture									
1	1.34	1.35	1.36	1.37	1.39	1.40	1.41	1.42	1.45
3	...	1.33	1.37	1.39	1.40	1.41	1.42	1.43	1.46
1A	1.33	1.36	1.37	1.39	...	...	...	...	...
2A	1.32	1.36	1.37	1.39	...	...	...	...	...
3A	1.34	1.37	1.39	1.40	...	...	...	...	...
4A	1.33	1.37	1.38	1.39	...	...	...	...	...
A	...	...	1.38	1.39	1.40	1.40	1.42	1.44	1.47
B	...	...	...	1.37	1.39	1.40	1.41	1.43	1.48
C	...	...	...	1.38	1.38	1.39	1.40	1.43	1.48
D	1.32	1.36	1.38	1.39	1.39	1.39	1.39	1.40	1.50
E	1.33	1.35	1.37	1.38	1.38	1.39	1.41	1.44	1.48
F	1.33	1.35	1.37	1.39	1.39	1.40	1.40	1.41	1.45
Average	1.330	1.356	1.374	1.386	1.390	1.397	1.407	1.425	1.471
16 to 1 Resultant Air-Vapor Mixture									
1	...	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.43
3	...	1.32	1.35	1.37	1.38	1.39	1.40	1.41	1.44
1A	1.32	1.34	1.35	1.37	1.38	...	...	...	...
2A	1.30	1.33	1.35	1.36	1.38	...	...	...	...
3A	1.32	1.35	1.36	1.38	1.39	...	...	...	...
4A	1.31	1.35	1.36	1.37	1.38	...	...	...	...
A	...	...	...	1.38	1.38	1.39	1.40	1.42	1.45
B	...	...	...	...	1.37	1.37	1.38	1.40	1.43
C	...	...	...	...	1.37	1.37	1.38	1.40	1.45
D	1.29	1.33	1.35	1.37	1.38	1.38	1.37	1.38	1.48
E	1.29	1.33	1.35	1.36	1.37	1.37	1.39	1.42	1.46
F	1.29	1.31	1.34	1.36	1.37	1.38	1.38	1.39	1.43
Average	1.303	1.333	1.351	1.368	1.377	1.379	1.386	1.403	1.446
12 to 1 Resultant Air-Vapor Mixture									
1	...	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.41
3	...	...	1.33	1.35	1.36	1.37	1.37	1.39	1.41
1A	1.30	1.32	1.33	1.35	1.36	1.37	...	...	...
2A	1.28	1.31	1.33	1.34	1.35	1.36	...	...	...
3A	1.30	1.33	1.34	1.35	1.36	1.38	...	...	...
4A	1.29	1.33	1.34	1.35	1.36	1.38	...	...	...
A	...	...	...	...	...	1.38	1.39	1.41	1.44
B	...	...	...	...	...	1.36	1.36	1.37	1.39
C	...	...	...	...	...	1.36	1.37	1.39	1.43
D	1.26	1.30	1.33	1.34	1.35	1.35	1.35	1.36	1.46
E	1.27	1.31	1.33	1.34	1.34	1.35	1.37	1.40	1.43
F	1.26	1.29	1.32	1.34	1.35	1.36	1.36	1.37	1.40
Average	1.280	1.314	1.331	1.344	1.353	1.365	1.367	1.384	1.421

[11] Based on the absolute-temperature scale.

A general comparison of these temperature ratios with those calculated from the work of Brown[12], who used a modified Sligh apparatus, is not possible. Although a wide temperature range was employed, experimentation was limited to one mixture supplied; namely, the 12 to 1 mixture. At 60 per cent evaporated, a 20 to 1 resultant air-vapor mixture is formed and a comparison can be made at this point. Brown listed values for the equilibrium air-distillation and the A.S.T.M. temperatures for 26 gasolines at this percentage evaporated. The average of the ratios of the absolute temperatures for these samples is 1.421 ± 0.011 as compared with 1.397 obtained from the present work. The difference is greater than would be anticipated and is in the wrong direction because of lack of equilibrium conditions in his apparatus. No mention seems to have been made by him of the precise significance attached to the percentages used in recording the equilibrium air-distillation data. If these were expressed on a volume basis the above difference would be decreased materially when corrected to a weight basis comparable with the results given in this report; but this correction cannot be made, since no record is given of the specific gravities of the residues.

[12] See University of Michigan Engineering Research Bulletin No. 7, 1927.

TABLE 7—AVERAGES OF RATIOS[13] FROM TABLE 6

Ratio	Per Cent 10	20	30	40	50	60	70	80	90
20 to 1	1.330	1.356	1.374	1.386	1.390	1.397	1.407	1.425	1.471
16 to 1	1.303	1.333	1.351	1.368	1.377	1.379	1.386	1.403	1.446
12 to 1	1.280	1.314	1.331	1.344	1.353	1.365	1.367	1.384	1.421
Average	1.304	1.334	1.352	1.369	1.373	1.380	1.387	1.404	1.446

[13] Ratio 20 to 1 = Average + 0.02; and ratio 12 to 1 = Average − 0.02.

The temperature ratio R_{16} for the 16 to 1 mixture can be related to the percentage evaporated by means of the equation

$$R_{16}=1.372\pm45\times10^{-6}(P-50)^2 \qquad (11)$$

where P is the percentage evaporated. The plus sign applies to values of P above 50 and the minus sign to those below 50 per cent. The average deviation between the observed ratios and those calculated from the equation is 0.003, which is within the experimental error of the measurements. A plot of these ratios for the 16 to 1 mixture against P is shown in Fig. 4, together with the curve given by the equation.

At any given percentage evaporated, the temperature ratio for any mixture within the range covered by the experimental work can be expressed by the relation

$$R=R_{16}+5\times10^{-3}(M-16) \qquad (12)$$

where M is the resultant air-vapor mixture. Equations (11) and (12) can be combined to give

$$R=1.372+5\times10^{-3}(M-16)\pm45\times10^{-6}(P-50)^2 \qquad (13)$$

from which R can be obtained for any value of P from 5 to 90 and for any value of M from 8 to 1 to 20 to 1. Values of the ratio for percentages less than 5

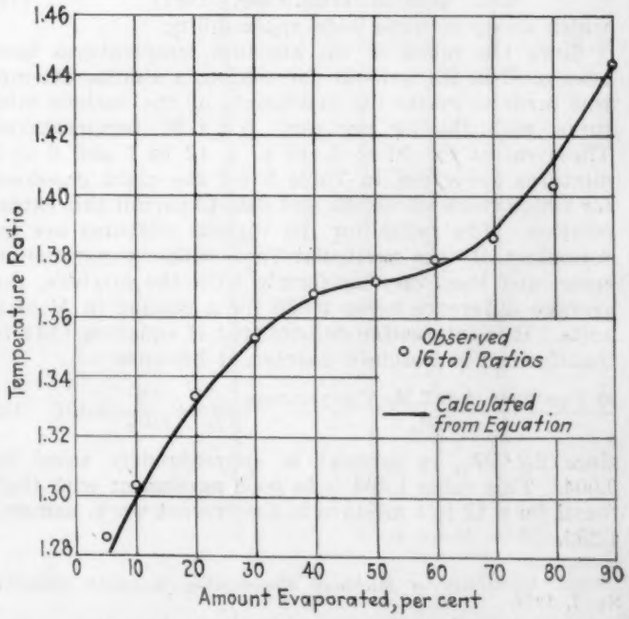


FIG. 4—RATIOS FOR THE 16 TO 1 MIXTURES PLOTTED AGAINST P, THE PERCENTAGE EVAPORATED

The Average Deviation of the Observed Ratios from Those Calculated Is 0.003, Which Is within the Experimental Error of the Measurements. The Solid-Line Curve Results from Equation (11)

are uncertain due to the effect of thermometer lag on this portion of the A.S.T.M. curve; whereas, a similar uncertainty is introduced when P is greater than 90 due to the small amount of liquid in the distillation flask.

Dew-Points Considered

Considerable interest is attached to the temperatures of these resultant mixtures when P is equal to 100, namely, the dew-point, on account of their bearing on the problem of normal engine operation. These temperatures can be obtained from the results of the equilibrium air-distillation method by a slight extrapolation, but this is impracticable in the case of the A.S.T.M. distillation curve. Brown[14] has suggested the following relation between the dew-points for a 12 to 1 resultant mixture and the 90-per cent point on the A.S.T.M. curve.

$$DP_{12}\,(\text{Deg. Fahr.}) = 5/7\,[90 \text{ per cent A.S.T.M. Temperature (Deg. Fahr.} - 186)] \quad (14)$$

which seems to have wide applicability.

Since the ratios of the absolute temperatures have been used in the general correlation, a similar attempt was made to relate the dew-points of the various mixtures with the 90 per cent A.S.T.M. temperatures. These ratios for 20 to 1, 16 to 1, 12 to 1 and 8 to 1 mixtures are given in Table 8 for the eight gasolines for which there were sufficient data to permit this extrapolation. The ratios for the various mixtures are independent of the particular fuel, within experimental error, and they vary uniformly with the mixture, the average difference being 0.025 for a change in M of 2 units. It is interesting to note that if equation (14) is transformed to absolute degrees, it becomes

$$\frac{90 \text{ Per Cent A.S.T.M. Temperature}}{DP_{12}} = 1.4 + \frac{2.2}{DP_{12}} = 1.404 \quad (15)$$

since $2.2/DP_{12}$ in general is approximately equal to 0.004. This value 1.404 is in good agreement with that found for a 12 to 1 mixture in the present work, namely, 1.399.

TABLE 8—COMPARISON OF 90 PER CENT A.S.T.M. TEMPERATURE WITH THE DEW-POINTS OF VARIOUS RESULTANT MIXTURES[15]

Fuel Sample No.	Resultant Mixtures 20 to 1		16 to 1		12 to 1		8 to 1	
	DP_{20}	R_{20}	DP_{16}	R_{16}	DP_{12}	R_{12}	DP_8	R_8
1	56 (132.8)	1.44	61 (141.8)	1.41	66 (150.8)	1.39	72 (161.6)	1.37
3	52 (125.6)	1.45	57.5 (135.5)	1.42	63.5 (146.3)	1.40	70 (158.0)	1.37
A	52.5 (126.5)	1.44	56.5 (133.7)	1.42	60.5 (140.9)	1.41	66 (150.8)	1.38
B	1 (33.8)	1.48	11 (51.8)	1.43	21 (69.8)	1.38	27.5 (81.5)	1.35
C	35.5 (95.9)	1.45	42 (107.6)	1.42	47.5 (117.5)	1.40	52.5 (126.5)	1.37
D	54 (129.2)	1.45	60 (140.0)	1.42	66 (150.8)	1.40	72 (161.6)	1.37
E	53 (127.4)	1.45	57.5 (135.5)	1.43	62.5 (144.5)	1.41	67.5 (153.5)	1.39
F	53.5 (128.3)	1.44	58.5 (137.3)	1.42	63.5 (146.3)	1.40	... (....)	...
Average		1.450		1.421		1.399		1.371

[15] Based on the absolute-temperature scale. The dew-point temperatures are in degrees centigrade, the fahrenheit equivalents being stated within the parentheses.

Direct comparison between the results reported here and the dew-point relations given by Stevenson and Stark[16] and by Stevenson and Babor[17] is not possible, since these investigators express the dew-points of the air-vapor mixtures in graphical form as a function of the Deppé end-points, and the latter have not been determined for the gasolines used in the present experiments. Stevenson and Stark give the 95 per cent A.S.T.M. distillation temperatures for the six samples used by them and Stevenson and Babor give the distillation curves for seven additional samples, the Deppé end-points being recorded for all 13 gasolines. The ratio of the absolute temperatures of the 95 per cent A.S.T.M. distillation points and the Deppé end-points for these 13 samples is found to be 1.125. In obtaining this ratio, allowance was made for loss in the A.S.T.M. distillation results, correction for which does not appear to have been made originally.

On the basis of data for 20 gasolines, it was found that correction for loss decreases the 95-per cent temperature by 4 deg. cent. (7.2 deg. fahr.) with an average deviation of 1 deg. cent. (1.8 deg. fahr.). Hence, the distillation values given by Stevenson and Stark and by Stevenson and Babor were corrected by subtracting 4 deg. cent. (7.2 deg. fahr.) in each case from the 95-per cent temperatures. If this relation between the A.S.T.M. temperatures and the Deppé end-points is assumed to be general, then it is possible to calculate the latter for the gasolines used in the present work and to read from the curves given in these papers corresponding values of the dew-points. These values are given in Table 9 in which, for comparison, are listed those calculated by the formula of Brown and those computed from the ratio found in the present correlation. The values obtained from the curves recently presented by Stevenson and Babor do not agree very well with those taken from the previous curves of Stevenson and Stark, the agreement with the observed values being considerably better on the basis of the earlier work. Values computed from the rule proposed by Wilson and Barnard[19] are not included, but the average deviation is about 17 deg. cent. (30.6 deg. fahr.).

TABLE 9—COMPARISON OF OBSERVED AND CALCULATED DEW-POINTS FOR A 12 TO 1 RESULTANT MIXTURE

Gasoline No.	Observed		Calculated: Present Correlation		Brown		Stevenson and Stark		Stevenson and Babor	
	Deg. Cent.	Deg. Fahr.[18]	Deg. Cent.	Deg. Fahr.[18]	Deg. Cent.	Deg. Fahr.[18]	Deg. Cent.	Deg. Fahr.[18]	Deg. Cent.	Deg. Fahr.[18]
1	66	150.8	64	147.2	63	145.4	65	149.0	61	141.8
3	63.5	146.3	63	145.4	62	143.6	63	145.4	59	138.2
A	60.5	140.9	62	143.6	61	141.8	62	143.6	58	136.4
B	21	69.8	17	62.6	16	60.8	..	....	..	....
C	47.5	117.5	46	114.8	45	113.0	52	125.6	52	125.6
D	66	150.8	65	149.0	64	147.2	71	159.8	67	152.6
E	62.5	144.5	64	147.2	63	145.4	65	149.0	61	141.8
F	63.5	146.3	64	147.2	63	145.4	63	145.4	59	138.2
Average Deviation			1.6	2.9	1.9	3.4	2.3	4.1	3.3	5.9

[18] Approximate.

Chart for the Estimation of Volatility

For convenience in the computation of volatility from the A.S.T.M. data, an alignment chart was constructed which is shown in Fig. 5. The numerals on the left side of the three oblique scales represent percentages evaporated on both the A.S.T.M. and the equilibrium air-distillation curves, forming in the case of the latter resultant air-vapor mixtures of 20 to 1, 16 to 1 and 12 to

[14] See University of Michigan Engineering Research Bulletin No. 7, 1927.

[16] See *Industrial and Engineering Chemistry*, July, 1925, p. 679.

[17] See *Industrial and Engineering Chemistry*, December, 1927, p. 1361.

[19] See *Industrial and Engineering Chemistry*, October, 1921, p. 906.

1 respectively. There is one such oblique scale for each of these three mixtures and they are designated as the *P*-20, *P*-16 and *P*-12 scales respectively. The three vertical scales on the right, *T*-20, *T*-16 and *T*-12, represent equilibrium air-distillation temperatures in degrees centigrade for the same three mixtures. On the middle scale are marked A.S.T.M. temperatures in degrees centigrade.

The use of the foregoing chart can be illustrated most simply by a few numerical examples. If it is desired to know the equilibrium air-distillation temperature which will just give a 20 to 1 air-vapor mixture at 50 per cent evaporated from a fuel whose A.S.T.M. temperature at 50 per cent evaporated is 140 deg. cent. (284 deg. fahr.), connect 50 on *P*-20 with 140 on the A. S. T. M. scale by means of a straight edge or thread and extrapolate to the *T*-20 scale. This intersection will give the desired temperature which, in the present example, is 23 deg. cent. (73 deg. fahr.). The solution for the temperature on the A.S.T.M. distillation curve at 75 per cent evaporated which will just give a 12 to 1 mixture at 55 deg. cent. (131 deg. fahr.) and 75 per cent evaporated will be given by connecting 75 on *P*-12 to 55 on *T*-12 and reading the desired temperature from the A.S.T.M. scale, which is 180 deg. cent. (356 deg. fahr.). Solutions for other values and for other similar problems can readily be obtained with accuracy, if two precautions are observed. Corresponding scales such as *P*-12 with *T*-12, *P*-16 with *T*-16 and *P*-20 with *T*-20 must be used and, further, the temperatures on the A.S.T.M.

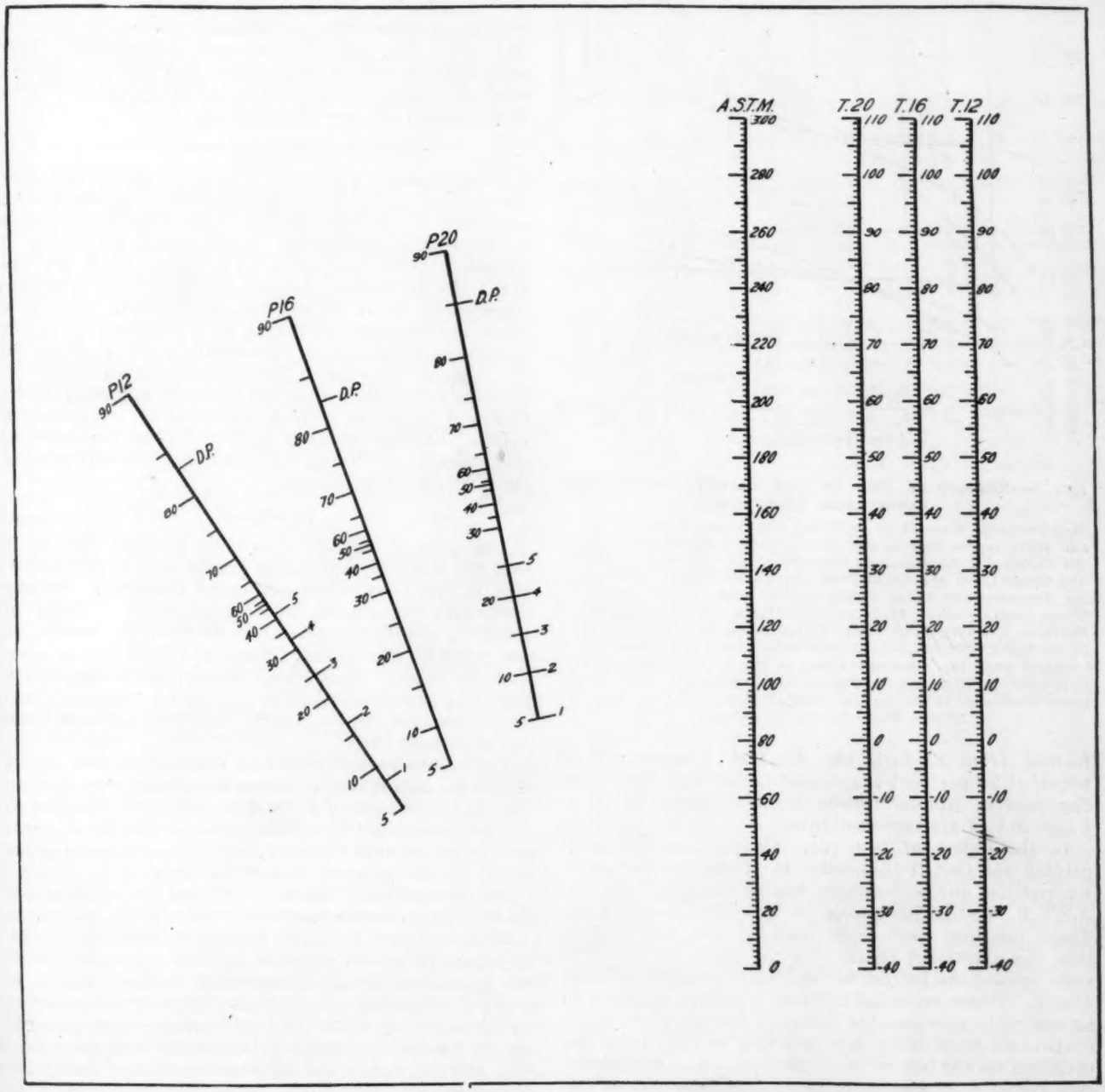


FIG. 5—ALIGNMENT CHART FOR COMPUTING VOLATILITY FROM THE A.S.T.M. DATA

and the *T* scales must apply to the same percentages evaporated, with the one exception mentioned in connection with dew-points in the following paragraph.

On the right of each of the *P* scales toward the top is an individual mark, which can be used for evaluating the dew-points of these three mixtures for any gasoline whose A.S.T.M. temperature at 90-*per cent evaporated* is known. For example, if the mark labeled *DP* on *P*-12 is connected to 200 on the A.S.T.M. scale, the intercept on the *T*-12 scale is 65 deg. cent. (149 deg. fahr.), which is the dew-point of a 12 to 1 mixture

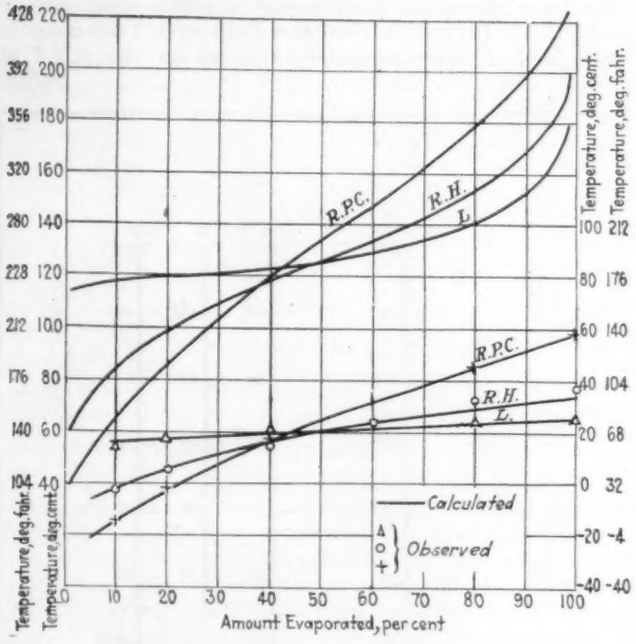


FIG. 6—RESULTS OF TEST OF THE VALIDITY OF GENERAL-CORRELATION RELATIONS

Measurements Were Made on Three Additional Gasolines, *RH, L* and *RPC*, in the Equilibrium Air-Distillation Apparatus To Test the Validity of the Relations Obtained in the General Correlation. The Upper Lines Are the A.S.T.M. Distillation Curves, Corresponding Temperatures Being Shown on the Scale at the Left. The Three Lower Curves Apply to the 16 to 1 Resultant Air-Vapor Mixtures, Corresponding Temperatures Being Shown on the Scale at the Right. These Lower Curves Were Constructed from Values Obtained from the Alignment Chart in Fig. 5, While the Symbols Represent the Experimental Points. The Agreement Is Good and Gives Confidence in the General Validity of the Relations Obtained from a Study of the 12 Gasolines.

formed from a fuel, the A.S.T.M. temperature of which at 90 per cent evaporated is 200 deg. cent. (392 deg. fahr.). Similar results can be obtained for 16 to 1 and 20 to 1 air-vapor mixtures.

In the report of last year, Cragoe and Eisinger[20] pointed out that it is possible to predict temperatures for possible and satisfactory engine starting from the A.S.T.M. distillation curve of the fuel being used. These relations have been extended and incorporated into the alignment chart. On the right of the *P*-20 scale toward the bottom are five marks numbered from 1 to 5. These represent air-fuel mixtures supplied to an engine to give possible starting, and the percentages evaporated from these mixtures can be read from the divisions on the left of the *P*-20 scale. If a carbureter can supply a mixture only as rich as 1 to 1, and the A.S.T.M. temperature at 5 per cent evaporated is 44 deg. cent. (111 deg. fahr.), the intersection on the *T*-20 scale of the line through 1 on *P*-20 and 44 on the A.S.T.M. scale gives —30 deg. cent. (—22 deg. fahr.), which is the minimum engine temperature that will permit starting with this fuel. See Appendix 1.

On the other hand, if the air temperature is —40 deg. cent. (—40 deg. fahr.) and the carbureter on the car to be started will only deliver a mixture as rich as 2 to 1, the A.S.T.M. temperature of a fuel at 10 per cent evaporated which will permit starting must not be higher than 35 deg. cent. (95 deg. fahr.), as can be seen by connecting 2 on *P*-20 with —40 on *T*-20 and reading the value on the A.S.T.M. scale. The marks on the right of the *P*-12 scale toward the bottom represent air-fuel mixtures supplied by the carbureter to give satisfactory starting. Reading from the bottom up, the corresponding percentages evaporated are 8.3, 16.7, 25.0, 33.3 and 41.7 per cent respectively. This scale must be used in conjunction with the *T*-12 and the A.S.T.M. scales, and the method of use is identical with that outlined for possible starting.

TEST OF GENERAL CORRELATION

Measurements were made on three additional gasolines, *RH, L* and *RPC* in the equilibrium air-distillation apparatus to test the validity of the relations obtained in the general correlation. These results are shown in graphical form in Fig. 6. The upper lines are the A.S.T.M. distillation curves, corresponding temperatures being shown on the scale at the left. The three lower curves apply to the 16 to 1 resultant air-vapor mixtures, corresponding temperatures being shown on the scale at the right. These lower curves were constructed from values obtained from the alignment chart in Fig. 5, while the symbols represent the experimental points. The agreement is good and gives confidence in the general validity of the relations obtained from a study of the 12 gasolines.

SUMMARY

The general conclusion reached in this analysis is that the A.S.T.M. distillation curves give a true indication of the relative volatilities of gasolines. At any percentage evaporated, the volatilities of a series of gasolines are in the same order as the temperatures on the A.S.T.M. distillation curves, and bear simple relations to them. Thus, from the standard distillation tests, the complete volatility curves of interest in engine operation can be readily computed or read from the alignment chart.

The extensive generalization outlined in this report should be considered as somewhat preliminary, due to the limited number of fuels employed. It is planned to extend the number to include a greater variety of gasolines, in an attempt to verify or disprove the conclusions drawn on the basis of these 15 samples.

The correlation of the A.S.T.M. and the equilibrium-air distillation curves near the initial and the end-points is somewhat more uncertain than over the middle range. Experiments are in progress for the measurement of the dew-points by an independent method, and it is hoped that greater accuracy can be obtained over the initial range, up to 10 per cent evaporated, by extending the temperature range of the apparatus below 0 deg. cent. (32 deg. fahr.) and supplementing these data with measurements on vapor pressures and molecular weights.

[20] See THE JOURNAL, March, 1927, p. 353.

APPENDIX 1

Note on Fuel Requirements for Engine Starting

In the report submitted to the Society at the 1927 Annual Meeting, Cragoe and Eisinger[21] showed that there is a definite relation between fuel volatility and engine starting. In two representative cases, they found further that the ease of starting at any given temperature could be predicted from the A.S.T.M. distillation curve of the fuel. This analysis was based on data obtained with the equilibrium air-distillation apparatus while the latter was still somewhat in the experimental stage, and information was not available either on the departure of the measured equilibrium air-distillation results from equilibrium or on the specific gravities of the unevaporated fuel. In correcting the data to a weight basis, they were forced to make an estimate of the differences between percentages by volume and by weight. During the last year information has been obtained on the departure from equilibrium and on the specific gravities of the residues of the fuels used in the analysis of Cragoe and Eisinger. Recomputation of the ratios of the absolute temperatures of the A.S.T.M. and the equilibrium air-distillation curves leads to somewhat different temperatures corresponding to a given ease of starting, the general equations for these calculations being Nos. (16), (17), (18) and (19).

Cragoe and Eisinger showed that the number of engine revolutions required to start in actual engine-starting tests is related to the resultant air-vapor mixture formed at the same temperature and with the same supplied mixture in equilibrium air-distillations by the empirical equation (16), in spite of the reduced pressure and the lack of equilibrium in the engine.

$$\log_{10} M_r = -2/N + 1.301 \qquad (16)$$

where M_r is the resultant mixture and N is the number of engine revolutions. The mixture supplied to the engine by the carbureter is connected with the resultant mixture formed under equilibrium conditions, by the relation

$$M_s = 0.01\,PM_r \qquad (17)$$

where M_s is the supplied air-fuel mixture and P is the percentage evaporated. The ratio of the absolute temperatures on the A.S.T.M. and on the equilibrium air-distillation curves, namely,

$$\frac{\text{A.S.T.M. Temperature in Deg., Absolute}}{\text{Equilibrium Air-Distillation Temp. in Deg., Absolute}} = R \qquad (18)$$

is related to the resultant mixture and the percentage evaporated by means of the equation

$$R = 1.372 + 5\times10^{-3}(M_r - 16) - 45\times10^{-6}(P-50)^2 \qquad (19)$$

which holds *only to* 50 *per cent evaporated.* Since there are seven variables and only four equations, it is necessary to specify three variables to obtain a solution.

A specific example will illustrate the use of these equations. It is desired to find the temperature of the surroundings which will just permit starting with a 2 to 1 mixture of air and U. S. Motor gasoline supplied. In equation (16), N is equal to ∞, so that M_r becomes 20 to 1. Since M_s is taken as 2 to 1, according to equation (17), P is equal to 10. From equation (19), if 20 is substituted for M_r and 10 for P, R becomes 1.320. At 10 per cent evaporated, the maximum temperature allowable for U. S. Motor gasoline under the existing Government specifications is 84 deg. cent. (183 deg. fahr.), or 357 deg. cent. (642.6 deg. fahr.), absolute. Therefore, the equilibrium air-distillation temperature, or the temperature of the surroundings, will be given by equation (18), and is 270 deg. cent. (518 deg. fahr.), absolute, or —3 deg. cent. (+27 deg. fahr.), which is the minimum temperature that will permit starting with this gasoline and an engine in good mechanical condition.

[21] See THE JOURNAL, March, 1927, p. 353.

[24] See THE JOURNAL, July, 1927, p. 15.

TABLE 10—A.S.T.M. TEMPERATURES CORRESPONDING TO POSSIBLE AND SATISFACTORY STARTING AT 0 DEG. CENT. (32 DEG. FAHR.) FOR VARIOUS MIXTURES SUPPLIED

	Possible Starting (20 to 1)			Satisfactory Starting (13.1 to 1)		
		Temperature			Temperature	
Mixtures Supplied	Percentage Evaporated	Deg. Cent.	Deg. Fahr.[22]	Percentage Evaporated	Deg. Cent.	Deg. Fahr.[22]
1 to 1	5	83	181.4	7.5	76	168.8
2 to 1	10	88	190.4	15.0	83	181.4
3 to 1	15	92	197.6	22.5	88	190.4
4 to 1	20	96	204.8	30.0	93	199.4
5 to 1	25	99	210.2	37.5	96	204.8

[22] Approximate.

The A.S.T.M. distillation temperatures for starting at 0 deg. cent. (32 deg. fahr.) with various mixtures supplied are given in Table 10, corresponding to resultant mixtures of 20 to 1 and 13.3 to 1 ($N = \infty$ and 11.3 respectively). To present in tabular form the effect of variation in the engine temperature, two particular mixtures supplied will be *arbitrarily* chosen, namely, 1 to 1 and 2 to 1. The temperatures on the A.S.T.M. distillation curves necessary for possible starting ($N = \infty$, M_r = 20 to 1) and for satisfactory starting (N = 11.3, M_r = 13.3 to 1) at various engine temperatures are given in Table 11.

TABLE 11—A.S.T.M. TEMPERATURES CORRESPONDING TO POSSIBLE AND SATISFACTORY STARTING AT VARIOUS ENGINE TEMPERATURES

1 to 1 Air-Fuel Mixture Supplied

Engine Temperature		Possible Starting A.S.T.M. Temperature, 5 Per Cent Evaporated		Satisfactory Starting, A.S.T.M. Temperature, 7.5 Per Cent Evaporated	
Deg. Cent.	Deg. Fahr.[23]	Deg. Cent.	Deg. Fahr.[23]	Deg. Cent.	Deg. Fahr.[23]
30	86	122	252	114	237
20	68	109	228	101	214
10	50	96	205	89	192
0	32	83	181	76	169
—10	14	70	158	63	145
—20	—4	57	135	50	122
—30	—22	44	111	37	99
—40	—40	31	88	25	77

2 to 1 Air-Fuel Mixture Supplied

		10 Per Cent Evaporated		15 Per Cent Evaporated	
30	86	128	263	122	252
20	68	115	239	109	228
10	50	101	214	96	205
0	32	88	190	83	181
—10	14	75	167	70	158
—20	—4	62	144	57	135
—30	—22	48	118	44	111
—40	—40	35	95	31	88

[23] Approximate.

APPENDIX 2

Lean Explosive Limits of Cracked and Straight-Run Gasolines

At the 1927 Semi-Annual Meeting of the Society, a report[24] was presented on the lean explosive limits of cracked and straight-run gasolines. This report in-

cluded results computed from data of Lovell, Coleman and Boyd[25] on four of the fuels used in the Bureau of Standards starting tests. In these computations use was made of a plot, Fig. 7, contained in the paper by Sligh on Volatility Tests for Automobile Fuels[26]. In this Fig. 7, however, the values of the ordinates, that is, air-fuel ratios supplied, should be twice those published. Recomputation of the data leads to the following values for the lean explosive limits of these gasolines:

Fuel No.	2	3	6	7
Air-Fuel Ratio Supplied	7.0	1.4	1.8	8.4
Air-Fuel Ratio Lean Limit	18	22	23	22

The recomputed values for the lean explosive limits are richer than those obtained at the Bureau of Standards, namely, 24.8, by an amount comparable to the difference between the best value from the literature for pentane (26 to 27) and the value (23.2) found by Lovell, Coleman and Boyd in a calibration experiment.

[25] See *Industrial and Engineering Chemistry*, March, 1927, p. 389.

[26] See THE JOURNAL, August, 1926, p. 158.

Results of Two Detonation Surveys[1]

By H. K. CUMMINGS[2]

THE first of the detonation surveys referred to is an extension of the survey of current methods of measuring the anti-detonation qualities of motor fuels; the second is a survey of the relative detonation characteristics of available motor fuels as determined by the routine method of fuel testing now employed at the Bureau of Standards.

The survey of methods presented includes a reference to the apparatus and methods described in the 1927 report, and the information regarding laboratories Nos. 1, 2, 6, 8 and 10 is not repeated; but since the other five laboratories, Nos. 3, 4, 5, 7 and 9, use modified apparatus or methods, the paper presents information regarding them as well as similar data for other laboratories.

Comparative data on the apparatus and methods described in the paper are presented in a tabulation which includes 20 laboratories. Of these laboratories, at least half rely on the listening method. Most of those who use the bouncing-pin method probably will agree that the novice finds the bouncing-pin indicator as temperamental as the ear is indefinite, according to the author. Nearly all the engines used are water-cooled, but at least one laboratory reports that more satisfactory results are obtained with air-cooled engines. Only six L-head engines are included in the group, yet three of these are used at laboratories where the compression pressure rather than the compression ratio is varied to obtain audible detonation. The English laboratories supply heat at a constant rate to the air entering the carbureter, while more than half of the remaining laboratories maintain the carbureter air at some definite temperature above room temperature.

The survey of fuels presented by the author includes a brief description of the method of test and comparative results on (*a*) 15 samples of gasoline typical of current refinery production, and (*b*) 6 composite samples representing the average non-premium gasoline available to motorists in different sections of the Country. The data are presented in tabular form and commented upon by the author.

In the Appendix, distillation data and knock ratings for 20 branded British motor fuels are summarized. Knock ratings on 20 branded American gasolines purchased from filling stations in the St. Louis district are also given. These gasolines were rated at the laboratory of the Roxana Petroleum Corporation, where a Ricardo E-35 engine is used for routine fuel testing.

THE Steering Committee of the Cooperative Fuel Research recommended that the Bureau of Standards report to the Society at the 1928 Annual Meeting the results of two detonation surveys made during the last year. The first of these is an extension of the survey of current methods of measuring the anti-detonating qualities of motor fuels, which was reported at the 1927 Annual Meeting. The second is a survey of the relative detonation characteristics of available motor fuels, as determined by the routine method of fuel testing now employed at the Bureau of Standards.

In last year's report[3] the apparatus and methods used by the following laboratories were described in some detail, on the basis of published articles:

(1) Ricardo & Co., Ltd.
(2) British Air Ministry Laboratory
(3) General Motors Corporation, Research Laboratories, (Midgley and Boyd)
(4) Sun Oil Co., (Clayden)
(5) Ohio State University, (Charch)
(6) Armour Institute of Technology, (Roesch)
(7) University of Michigan, (Brown)
(8) Kansas City Testing Laboratory, (Cross)
(9) Universal Oil Products Co., (Egloff and Morrell)
(10) University of Iowa, (Olin, Read and Goos)

In discussion, R. E. Wilson described the test method used by the Standard Oil Co. of Indiana[4] and Prof. H. M. Jacklin the method which he was using at the Ohio State University[5]. The information regarding five of the foregoing laboratories, Nos. 1, 2, 6, 8 and 10, is believed to be substantially correct and need not be repeated here. The other five laboratories, Nos. 3, 4, 5, 7 and 9, use modified apparatus or methods and these are considered herewith.

Prof. W. E. Lay, at the University of Michigan, is using the National Advisory Committee for Aeronautics universal test engine[6] for research and routine testing and his set-up is shown in Fig. 1. The compression ratio of this engine can be varied by screwing the cylinder up and down as is the case with the Ricardo variable-compression engine, but the range available is from 3.3 to 1 to 15 to 1. The bore is 5 in. and the stroke is 7 in. as in the Liberty engine, but the combustion-

[1] Published by permission of the Director of the Bureau of Standards, City of Washington.

[2] S.M.S.A.E.—Associate physicist, Bureau of Standards, City of Washington.

[3] See THE JOURNAL, May, 1927, p. 599.

[4] See THE JOURNAL, May, 1927, p. 608.

[5] See THE JOURNAL, May, 1927, p. 612.

[6] See National Advisory Committee for Aeronautics Technical Report No. 250.

chamber and cylinder-wall are cooled by independent water-jackets. Valve timing and valve lift can also be varied while the engine is running. In general, the compression ratio giving maximum power at constant speed and mixture ratio is used for knock rating. Fixed spark-settings and optimum spark-advances have both been used.

A variable-compression engine which, according to Professor Jacklin[7], was constructed at Ohio State University from a Delco 2½ x 5-in. engine for a cash outlay of about $40, is shown in Fig. 2. Cylinder *A*, of 3 5/16-in. bore, is bolted on, replacing the regular cylinder-head and, within this cylinder, is mounted a piston carrying the valves. The piston, adjusted by the micrometer-screw *B*, has about ⅝ in. total vertical motion and gives compression ratios ranging from 3.5 to 1 to 6.5 to 1. This engine is water-cooled and is coupled to a small dynamometer. The relative detonation characteristics of fuels are judged either from the variation of brake horsepower with compression ratio at fixed spark-advance and mixture ratio or from indicator cards made with the Jacklin indicator. The engine is operated at a constant speed of 1090 r.p.m. with carbureter-air temperature at 38 deg. cent. (100 deg. fahr.) and water outlet-temperature at about 80 deg. cent. (176 deg. fahr.).

[7] See THE JOURNAL, May, 1927, p. 612.

[8] See Bulletin of the American Petroleum Institute, Jan. 31, 1927, p. 195.

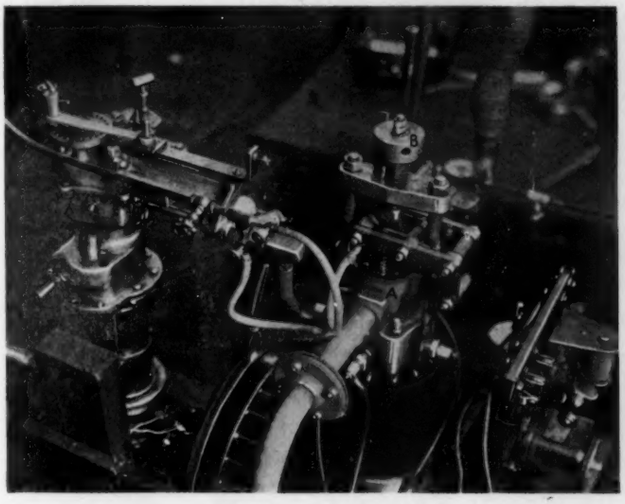


FIG. 2—VARIABLE-COMPRESSION ENGINE

This Engine Was Reconstructed from a Delco 2½ x 5-In. Engine at Ohio State University

At the research laboratories of the General Motors Corporation, the air-cooled Delco engine used in the work of Midgley and Boyd has been superseded[8] by a 5-hp. 3¼ x 4¼-in. water-cooled variable-compression

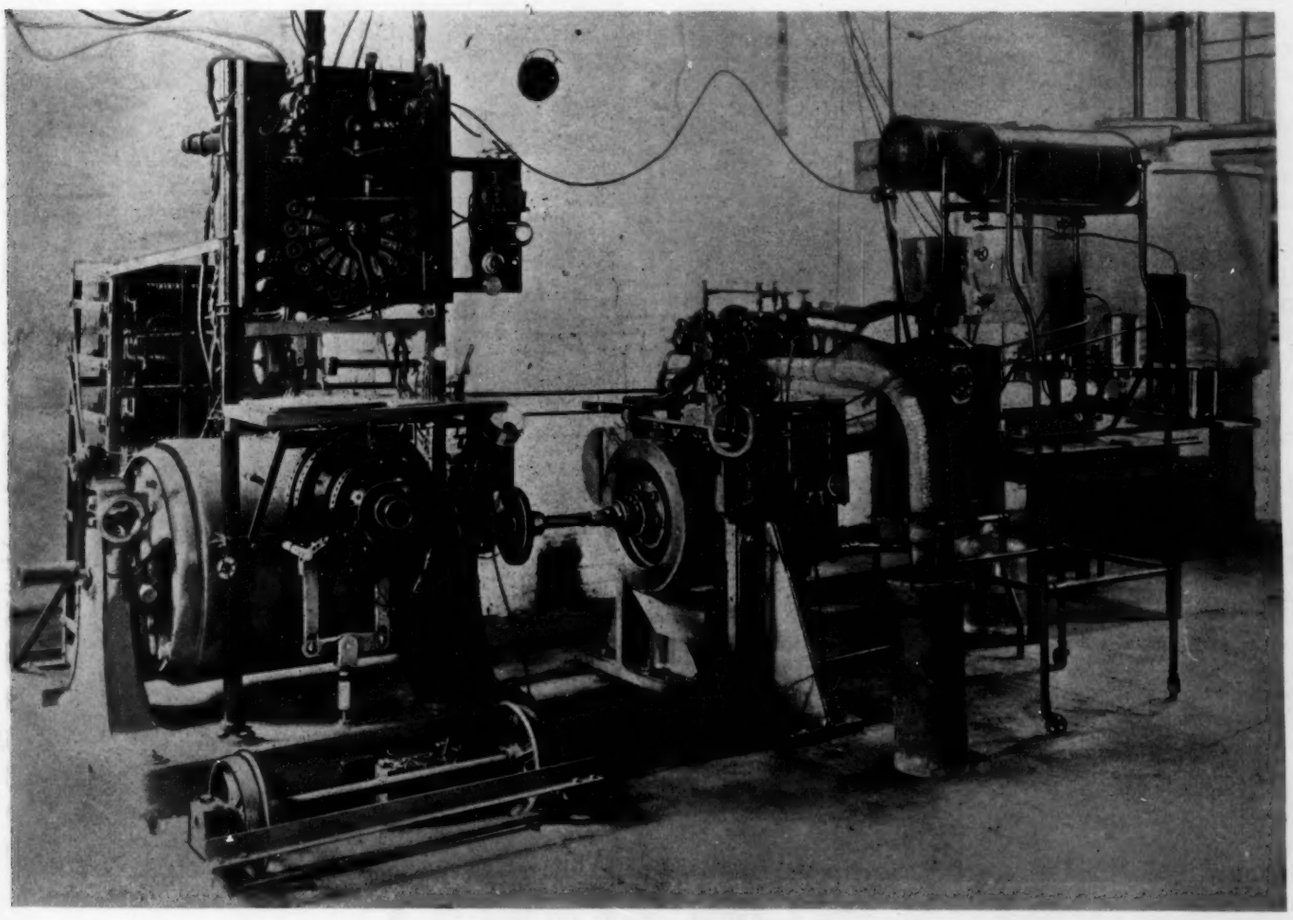


FIG. 1—UNIVERSAL TESTING ENGINE

The Engine Is of the National Advisory Committee for Aeronautics Type and Is Used for Research and Routine Testing at the University of Michigan

engine of special design fitted with a water-pump and a thermostat to maintain uniform water-temperature and coupled to a 15-hp. Sprague electric dynamometer. Fuel is metered to the engine through an adjustable mixing valve, supplied by either of two float-bowls which are adjustable for height relative to the engine and to each other. Accurate regulation of air-fuel ratio is secured by adjusting the level of each individual float-bowl relative to the jet. The compression ratio is varied until the engine gives a noticeable knock when running on the reference fuel, and the amount of ethyl fluid which must be added to the fuel under test to give the same knock intensity is determined by trial. Engine speed is kept constant, at 1000 r.p.m. or less, and the bouncing-pin indicator is used to compare knock intensities.

The Atlantic Refining Co. uses a 5-hp. single-cylinder water-cooled marine engine. This engine has a 4-in. stroke and its bore is reduced from 3¾ in. to 2⅞ in. by means of a steel liner pressed into the cylinder. A special bronze cylinder-head designed to give a compression ratio of 7 to 1 is used. The cooling water is independently circulated at a rapid rate, giving constant jacket-water temperature with little change in temperature through the jacket. A Zenith carbureter is used and the air is preheated to 60 deg. cent. (140 deg. fahr.). The carbureter is adjusted to give approximately a 12.5 to 1 mixture with a standard fuel, as determined by exhaust-gas analysis, and the setting is not changed throughout the tests. Operating conditions are: speed, 1200 r.p.m.; spark advance, 22 deg.; water temperature, 68 deg. cent. (155 deg. fahr.). Power is absorbed by means of a Prony brake. The throttle is gradually opened until audible detonation occurs and the manifold depression is recorded. Differences in manifold depression are reduced to benzol equivalents by means of an experimentally determined curve.

The Standard Oil Co. of Indiana employs the same modified marine engine as does the Atlantic Refining Co., but couples it to a 15-hp. Sprague electric dynamometer. A special Zenith carbureter is used, which is said to give a very constant mixture-ratio independent of fuel and throttle. The power developed at an air-fuel ratio of 11 to 1, when the throttle is opened until light detonation as judged by ear occurs, is taken as a preliminary measure of the knock rating. The final test is to add ethyl fluid until light detonation occurs at the same throttle setting for the two fuels under comparison.

The Texas Co. has been using for test purposes[9] a four-cylinder truck-engine of 4½-in. bore and 6¼-in. stroke, provided with high-compression cylinder-heads and coupled to a Sprague electric dynamometer. This set-up is shown in Fig. 3. The spark setting for all tests is for 32-deg. advance. Inlet jacket-water temperature is maintained at 38 deg. cent. (100 deg. fahr.), and the air going to the carbureter is heated to 93 deg. cent. (199 deg. fahr.). A Zenith carbureter is used, with the fixed setting recommended for commercial use, and the

[9] See THE JOURNAL, July, 1927, p. 60.

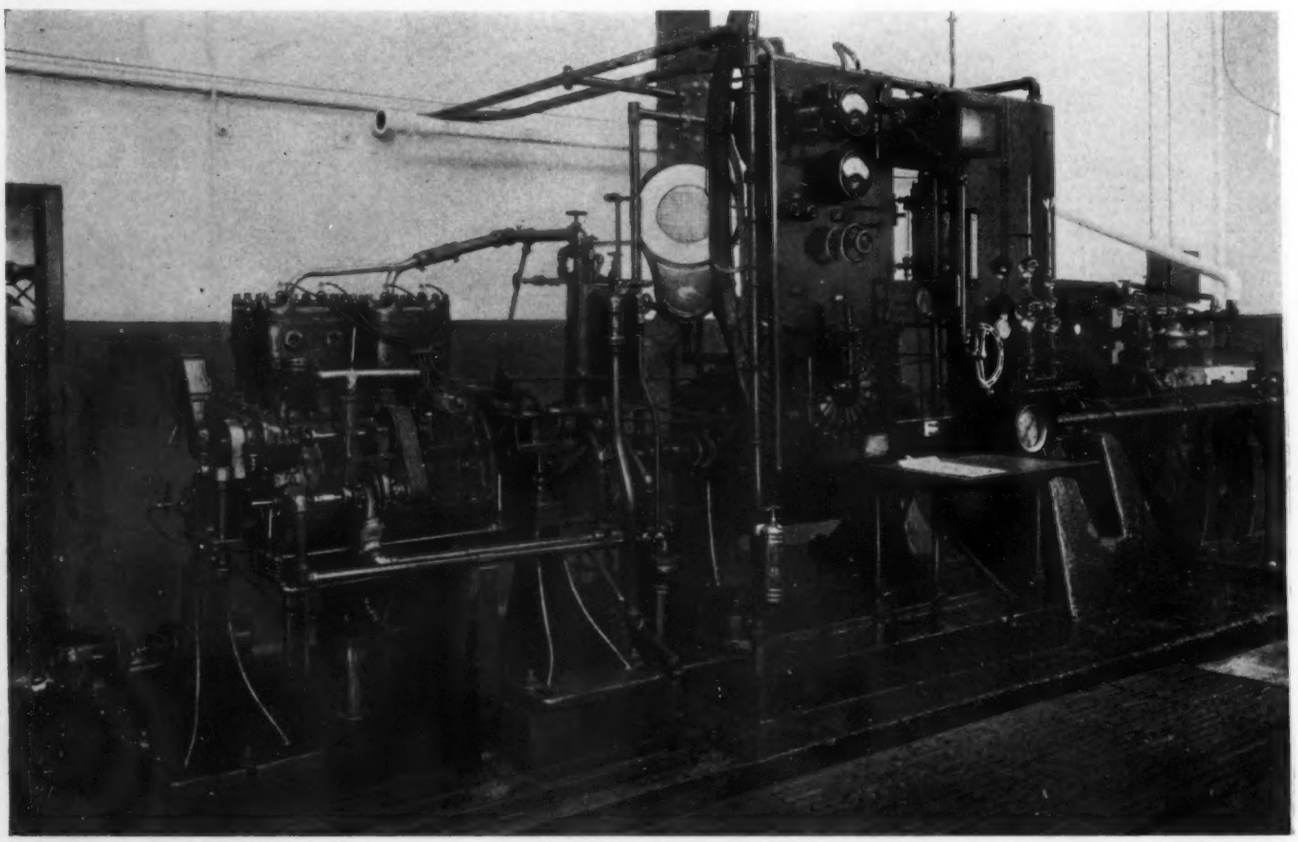


FIG. 3—ENGINE USED BY THE TEXAS CO.

This Is a Four-Cylinder Truck-Engine of 4½-In. Bore and 6¼-In Stroke. It Is Provided with High-Compression Cylinder-Heads and Is Coupled to a Sprague Electric Dynamometer

throttle is opened gradually at a constant speed of 400 r.p.m. until a standard intensity of knock as judged by ear occurs. The throttle opening is identified by measuring the manifold depression. Fuels are rated in terms of the number of parts of ethyl fluid which must be added to 1000 parts of a low-volatility straight-run paraffin to give a knock of standard intensity at the same manifold depression. The Texas Co. is also experimenting along similar lines with a single-cylinder marine engine modified to take a standard Liberty-engine cylinder. With this engine, a constant air-fuel ratio is maintained by metering both air and fuel.

Redesigned Marine Engine Used

Dr. G. G. Brown, at the University of Michigan, has discarded both the bomb and the air-cooled Delco engine in favor of a redesigned single-cylinder marine engine[10]. This engine has a 4-in. stroke and its bore is reduced from 3¾ in. to 2 11/16 in. by means of a steel sleeve inserted in the block. The cylinder-head is modified to give a compression ratio of 7.3 to 1. The engine is coupled to a 15-hp. Sprague electric dynamometer and operated at a constant speed of 1500 r.p.m. The carbureter air is preheated to 45 deg. cent. (113 deg. fahr.) and the jacket-water temperature is controlled by a thermostat, which gives an inlet-water temperature of 70 deg. cent. (158 deg. fahr.) and an outlet-water temperature of 80 deg. cent. (176 deg. fahr.). The carbureter is adjusted, if necessary, for maximum power with each fuel. The spark is varied and the spark advance for maximum torque is taken as the index of antiknock value. Benzol equivalents are obtained by matching fuels under test with blends of benzol and a reference fuel of low antiknock value.

The Standard Oil Co. of New Jersey uses an 850-watt Delco engine having a 2½-in. bore and a 5-in. stroke, of high enough compression ratio to give a distinct knock when operated at wide-open throttle and a speed of 1330 r.p.m. The power is absorbed by means of a mechanical brake. The air-fuel ratio is adjusted to about 13 to 1 for the standard reference-fuel, using exhaust-gas analysis. Unknown fuels are rated by finding the amount of tetraethyl lead or the percentage of benzol necessary to make the standard fuel match the unknown fuel, using the bouncing-pin indicator. For convenience in reporting results a numerical scale is employed on which the standard fuel is rated as 10 and a 50-50 blend of this fuel with benzol is rated as 0. To check the laboratory tests, a high-compression-engine automobile is operated at full throttle up a steep hill with the carbureter set for maximum power. Knock intensities with known and unknown fuels are compared by ear.

The A. D. Little Laboratories[11] use an 850-watt air-cooled Delco engine and generator with a variable separately excited field and special high-compression cylinder-heads. A fixed carbureter-setting is employed. The engine is operated at a constant speed of 1100 r.p.m. and the bouncing-pin indicator is used. The throttle is opened until the desired knock intensity is obtained with the fuel under test. This is matched against a standard reference-fuel blended with aniline. A preliminary estimate is made by loading the engine down and finding the speed at which it begins to knock.

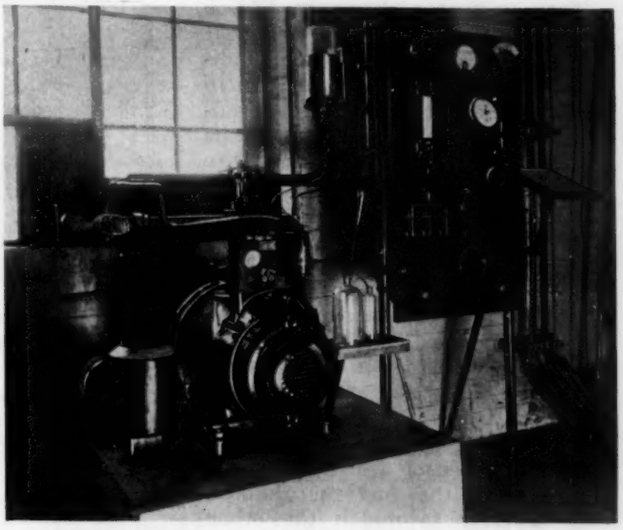


Fig. 4—Water-Cooled Delco Testing-Equipment

The Equipment Is Used by the Ethyl Gasoline Corporation, the Power Unit Consisting of a Standard 1250-Watt Set Equipped with a Special Water-Cooled Cylinder and Head of the Size Designed for the 850-Watt Set. The Compression Ratio Is about 6.4 to 1 and the Engine Is Operated at a Constant Speed of 1000 R.P.M.

The water-cooled Delco outfit used by the Ethyl Gasoline Corporation is illustrated in Fig. 4. The power unit consists of a standard 1250-watt set equipped with a special water-cooled cylinder and head of the size designed for the 850-watt set. The compression ratio is about 6.4 to 1 and the engine is operated at a constant speed of 1000 r.p.m. The fuel system permits quick changing from one fuel to another and the air-fuel ratio is adjusted separately for each fuel. The bouncing-pin indicator is used and the throttle is opened until a knock of suitable intensity is obtained with the standard fuel. The amount of tetraethyl lead required to bring an unknown fuel up to the standard is determined by successive trials. It is understood that this apparatus and method have been adopted for routine testing by the Sun Oil Co. in place of that previously described[12].

Comparison Tests To Rate Unknown Fuels

The Tide Water Oil Co. uses the equipment developed by the Ethyl Gasoline Corporation for the purpose of comparing unknown fuels with a suitable reference-fuel blended with benzol. A fixed throttle-setting is used for all tests and the mixture ratio is varied, by bleeding air into the manifold, to obtain maximum knock with each unknown fuel. Results are reported on a numerical scale somewhat similar to that employed by the Standard Oil Co. of New Jersey. There are two reference fuels, one rated at 15 and the other at 10, and a 50-50 blend of the better reference-fuel with benzol is understood to have a rating of 0.

At the Mellon Institute of Industrial Research[13], Gruse and his assistants are using a 1250-watt Delco engine and generator with the stock piston and cylinder replaced by the piston and air-cooled cylinder from an 850-watt engine of the same make. A compression ratio of 5.5 to 1 is obtained by means of a special water-cooled cylinder-head and the carbureter-air temperature is regulated by means of an exhaust stove. The special

[10] See University of Michigan Engineering Research Bulletin No. 7, p. 123.

[11] See *Industrial and Engineering Chemistry*, September, 1927, p. 1055.

[12] See *Automotive Industries*, Nov. 12, 1925, p. 813; see also The Journal, May, 1927, p. 602.

[13] See *Industrial and Engineering Chemistry*, February, 1927, p. 228; see also The Journal, February, 1927, p. 214.

ballistic indicator shown in Fig. 5 uses essentially the pressure-element of the original Midgley optical indicator with a weighted pointer in place of the optical lever. An adjustable water rheostat controls the load, and operating conditions are selected so that the standard reference-fuel will give a reading of about 20 on the indicator scale. By means of a three-way cock in the fuel line, it is possible to take alternate readings with the fuel under test and with the standard fuel. Results can be expressed directly in terms of indicator readings, for example, 20 to 35 for a fuel which knocked worse than the reference fuel, or the percentage of benzol which must be blended with the fuel that knocks most severely to match the other fuel can be determined definitely by trial.

In the laboratories of the Universal Oil Products Co. a modified 850-watt Delco engine and generator is used[14] with the ballastic indicator developed at the Mellon Institute. Air-cooling is retained for the cylinder-walls, but a special water-cooled head is substituted for the regular cylinder-head. The carbureter air is heated to 49 deg. cent. (120 deg. fahr.) by means of an exhaust stove, and the temperature of the cooling water leaving the head is kept constant at about 82 deg. cent. (180 deg. fahr.). The thickness of the gaskets used between crankcase and cylinder block and between cylinder-block and cylinder-head determines the compression ratio. An adjustable water-rheostat is used to maintain engine speed constant at 1550 r.p.m. The method of rating an unknown fuel is to find a spark advance which gives an indicator reading between 15 and 20 and then to locate by trial the blend of chemically pure benzene and straight-run Pennsylvania gasoline which gives the same intensity of detonation at the same spark setting.

[14] See THE JOURNAL, March, 1927, p. 405.

FIG. 5—MELLON INSTITUTE DETONATION INDICATOR

The Special Ballistic Indicator Uses Essentially the Pressure-Element of the Original Midgley Optical Indicator with a Weighted Pointer in Place of the Optical Lever. An Adjustable Water Rheostat Controls the Load, and Operating Conditions Are Selected So That the Standard Reference-Fuel Will Give a Reading of about 20 on the Indicator Scale

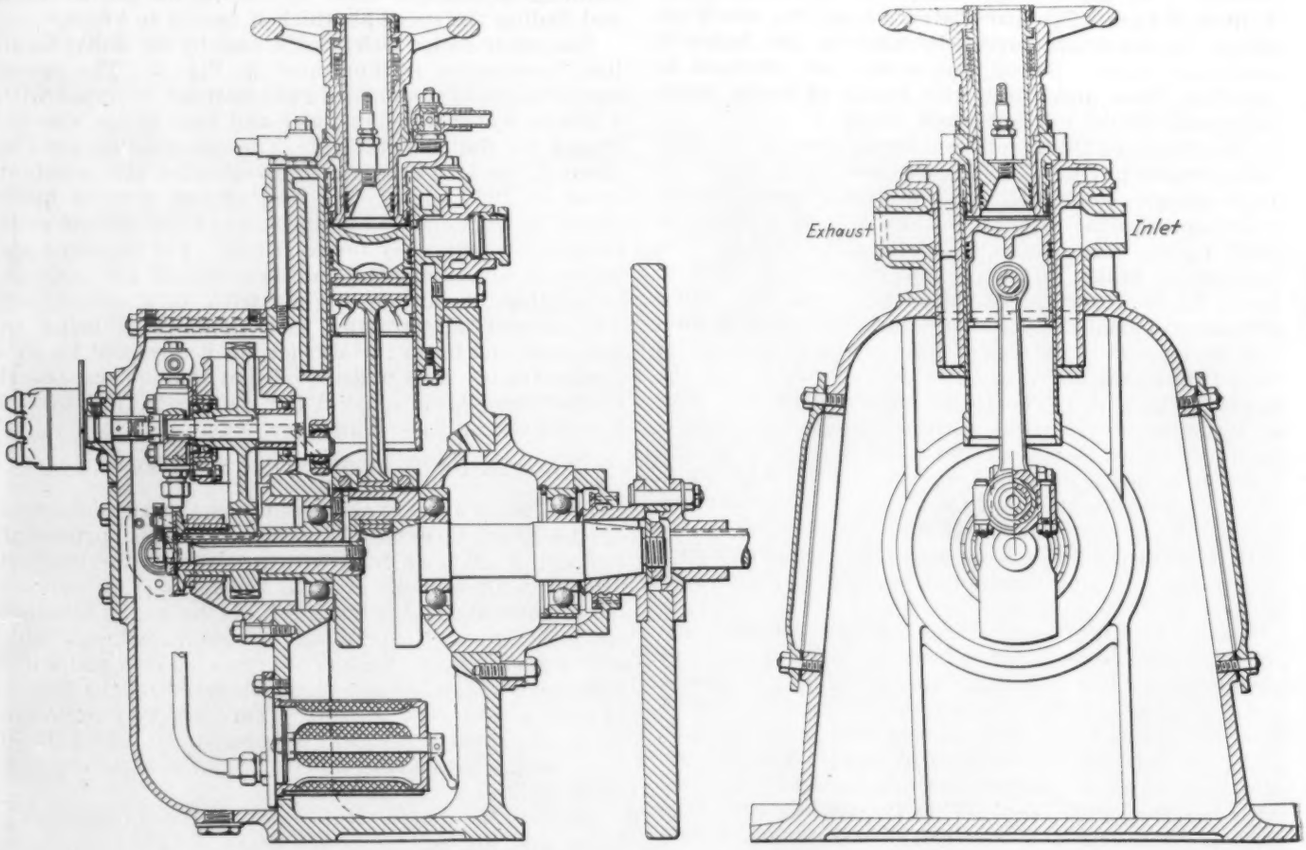


FIG. 6—RICARDO SLEEVE-VALVE VARIABLE-COMPRESSION ENGINE

The Engine Is of the Single-Sleeve Type and Has a Cone-Shaped Combustion-Chamber Equipped with a Central Spark-Plug. The Cylinder-Head Is Detachable and Consists of an Inner and an Outer Casting, the Space between Them Forming the Water-Jacket for the Head. The Inner Casting Can Be Screwed In and Out by Means of a Handwheel To Vary the Compression Ratio between 5 to 1 and 10.75 to 1. The Engine Has a 2⅞-In. Bore and 3¼-In. Stroke, a Connecting-Rod of Duralumin, and an Aluminum-Alloy Piston. It Is Quieter and Cheaper than the Ricardo Overhead-Valve Variable-Compression Engine

TABLE 1—SURVEY OF METHODS

Laboratory	Engine	Cooling	Number of Cylinders	Bore and Stroke, In.	Speed, R.P.M.	Compression Ratio	Load	Detonation Indicator	Basis of Knock Rating
Ricardo & Co., Ltd.	Supercharging	Water	1	4⅜x5½	1,500	5.18	Dynamometer	Ear	Toluene Value or Indicated Mean Effective Pressure
Ricardo & Co., Ltd.	Variable Compression, Valve-in-Head	Water	1	4½x8	1,500	3.7 to 8	Dynamometer	Ear	Toluene Value or Highest Useful Compression Ratio
Ricardo & Co., Ltd.	Variable Compression, Sleeve Valve	Water	1	2⅞x3¼	1,500	5 to 10.8	Dynamometer	Ear	Highest Useful Compression Ratio
British Air Ministry Laboratory	Variable Compression, E35	Water	1	4½x8	1,500	3.8 to 7.9	Dynamometer	Ear	Per Cent Change in Highest Useful Compression Ratio
University of Michigan Department of Mechanical Engineering	Variable Compression, NACA Universal	Water	1	5 x7	1,000	3.3 to 15	Dynamometer	Ear or Power Loss	Compression Ratio Giving Maximum Brake Horsepower
Ohio State University	Variable Compression, Modified Delco	Water	1	2½x5	1,090	3.5 to 6.5	Dynamometer	Ear or Power Loss	Maximum Brake Horsepower
Kansas City Testing Laboratory	Variable Compression, Modified Novo	Water	1	5 x6	500	3 to 9	Generator	Ear, Indicator Card or Power Loss	Benzol Equivalent or Maximum Brake Horsepower
General Motors Corporation Research Laboratories	Variable Compression, Special	Water	1	3¼x4½	950	Varied	Dynamometer	Bouncing Pin	Et$_4$Pb Equivalent
Atlantic Refining Co.	Modified Marine Engine	Water	1	2⅞x4	1,200	7	Prony Brake	Ear	Benzol Equivalent
Standard Oil Co. of Indiana	Modified Marine Engine	Water	1	2⅞x4	1,200	6.5	Dynamometer	Ear	Et$_4$Pb Equivalent
Armour Institute of Technology	Automobile Engine	Water	4	3¼x5½	1,000	4.6 and 5.8	Dynamometer	Ear	Spark-Advance for Given Knock-Intensity
The Texas Co.	Truck Engine	Water	4	4½x6¼	400	4.7	Dynamometer	Ear	Et$_4$Pb Equivalent
University of Michigan Department of Chemical Engineering	Modified Marine Engine	Water	1	2 11/16x4	1,500	7.3	Dynamometer	Ear or Power Loss	Spark-Advance Giving Maximum Brake Horsepower or Benzol Equivalent
Standard Oil Co. of New Jersey	850-Watt High-Compression Delco Engine	Air	1	2½x5	1,350	Several Ratios	Prony Brake	Bouncing Pin	Et$_4$Pb Equivalent or Benzol Equivalent
Road Test	Automobile Engine	Water	6	3½x5	675+	6	Steep Hill	Ear	Et$_4$Pb Equivalent or Benzol Equivalent
Arthur D. Little, Inc.	850-Watt High-Compression Delco Engine	Air	1	2½x5	1,100	Several Ratios	Modified Generator	Bouncing Pin	Aniline Equivalent
Ethyl Gasoline Corporation	Modified Delco Outfit	Water	1	2½x5	1,000	6.4	Generator	Bouncing Pin	Et$_4$Pb Equivalent
Sun Oil Co.	Modified Delco Outfit	Water	1	2½x5	1,000	6.4	Generator	Bouncing Pin	Et$_4$Pb Equivalent
Tide Water Oil Co.	Modified Delco Outfit	Water	1	2½x5	1,000	7.4	Generator	Bouncing Pin	Benzol Equivalent
Mellon Institute	Special Delco Outfit	Air and Water	1	2½x5	1,000	5.5	Generator	Ballistic Device	Benzol Equivalent
Universal Oil Products Co.	Special Delco Outfit	Air and Water	1	2½x5	1,500	Several Ratios	Generator	Ballistic Device	Benzol Equivalent
Gulf Oil Co.	Special Delco Outfit	Water	1	2½x6	1,000	5.8	Generator	Bouncing Pin	Relative Detonation Intensity Cubic Centimeters of Gas Evolved per Minute
University of Iowa	Motorcycle Engine	Air	2	3 7/16x4	1,400	4.5	Prony Brake	Ear	Brake Mean Effective Pressure for Incipient Knock

The Gulf Oil Co. employs for fuel testing[15] the 3-kw. Delco engine and generator, replacing the stock cylinder and piston by those of the 850-watt outfit. This provides an engine of 2½-in. bore and 6-in. stroke, suitable high compression being obtained by machining off the underside of the cylinder-head. An open copper tank built around the cylinder permits adequate water-cooling of cylinder-wall and head. The cooling water is circulated at such a rate that its outlet temperature is around 80 deg. cent., say 170 to 180 deg. fahr. The carbureter is set to give a maximum power-mixture, as checked by exhaust-gas analysis, and the spark is adjusted independently for maximum power. Two reference fuels are used: (*a*) a knock standard which is a selected straight-run Oklahoma gasoline, and (*b*) a non-knocking standard which is either the same gasoline treated with 4.5 ml. (1 ml. = 1 milliliter = 1.000027 cc.) of ethyl fluid per gal. or a blend of 45 per cent benzene and 55 per cent Oklahoma gasoline. The bouncing-pin indicator is used and a "knock-number" is determined for each fuel from the volume of gas evolved in the same length of time by the unknown fuel and by each reference fuel. A small ammeter is sometimes used in place of the electrolytic cell and gives practically the same rating.

Ricardo has recently designed a variable-compression-engine testing-set[16] which is more quiet and less expensive than his overhead-valve variable-compression engine. Fig. 6 shows sectional views of this engine, which is of the single-sleeve type and has a cone-shaped combustion-chamber with a central spark-plug. The cylinder-head is detachable and consists of an inner and an outer casting, the space between them forming the water-jacket for the head. The inner casting can be screwed in and out by means of a handwheel, to vary the compression ratio between 5 to 1 and 10.75 to 1. The engine has a 2⅞-in. bore and 3¼-in. stroke, a connecting-rod of duralumin and an aluminum-alloy piston.

Comparative Data

Comparative data on the apparatus and methods herein described are shown in Table 1, in which 20 laboratories are considered. Since this list includes most of

[15] See Bulletin of the American Petroleum Institute, Jan. 31, 1927, p. 198.

[16] See *Engineering*, May 27, 1927, p. 638.

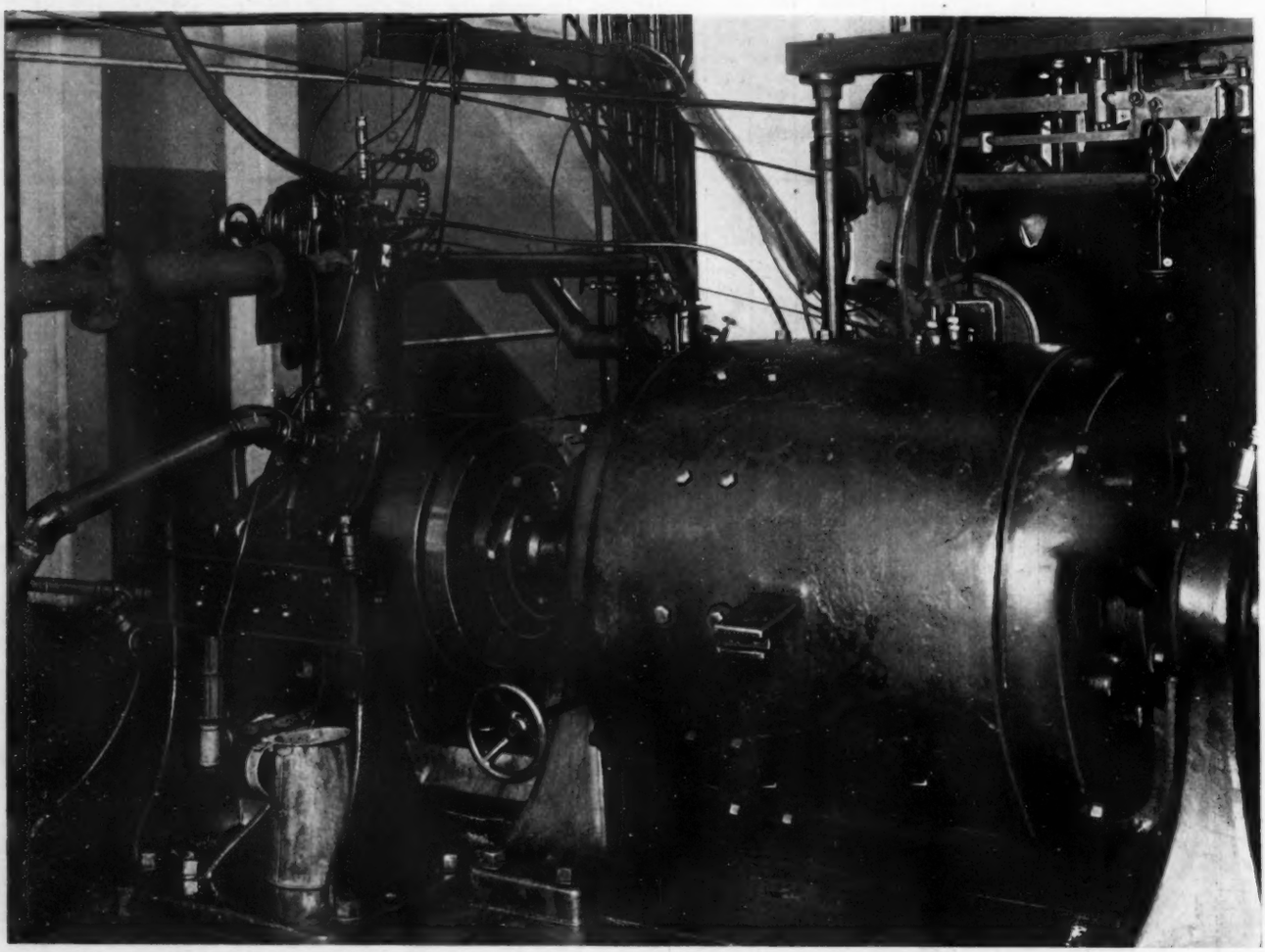


Fig. 7—Bureau of Standards Single-Cylinder Liberty Testing-Engine

The Engine Is Coupled to an Electric Dynamometer and Is Operated at 1500 R.P.M. for a Series of Mixture-Ratio Runs with the Spark Set for Maximum Power in the Absence of Detonation, That Is, at About 30-Deg. Advance. The Throttle Is Initially Adjusted So That, with the Reference Fuel, Detonation Is Audible Throughout Most of the Mixture-Ratio Range but Is Not Excessive at Any Carbureter Setting. Runs Are Made at the Foregoing Throttle-Setting, Using Air-Fuel Ratios Ranging from Full Rich to Full Lean. The Maximum Indicated Horsepower Obtained Is Termed the "Maximum Permissible Power"

TABLE 2—DATA ON REFINERY SAMPLES

Sample No.	Description[17]	Knock Rating	Specific Gravity, A. P. I. Deg.	Initial Boiling-Point, Deg. Fahr.	Distillation Temperatures, Deg. Fahr. 20 Per Cent	50 Per Cent	90 Per Cent	Dry	Recovery, Per Cent
1	Salt Creek, SR	98	...	...	...	...	...	...	...
2	Salt Creek, CR	104	...	...	...	...	...	...	...
3	Pennsylvania, SR	89	61.5	122	216	271	360	444	98
4	Commercial (Pa.)	104	56.9	100	194	280	392	428	96
5	Commercial (N. J.)	110	60.2	108	187	262	358	405	97
6	Smackover, BlS	117	57.7	109	199	255	345	405	98.5
7	Los Angeles, SR	125	56.9	109	198	243	329	401	98.5
8	Los Angeles, SR	120	56.2	102	196	261	349	392	97.5
9	Oklahoma, SR	95	57.9	117	219	277	349	392	98
10	Ohio	97	60.0	109	225	268	334	383	97.5
11	Los Angeles, SR	122	52.7	108	221	282	388	439	98
12	Spindletop, SR	117	52.3	144	223	270	352	405	98
13	Spindletop, CR	130	48.3	88	208	320	403	432	96
14	Amarillo, SR	93	56.9	113	212	298	388	430	98
15	Amarillo, CR	104	54.4	100	212	311	401	430	98
16	Commercial, Refinery	100	57.2	111	208	277	390	435	97

[17] SR indicates "straight-run"; CR, "cracked"; and BlS, "blending stock."

the laboratories taking part in the comparative tests arranged by the Ethyl Gasoline Corporation and The Texas Co., numerous examples of the ratings which these various methods give for the same fuels will be found in the paper by Graham Edgar[18] and the paper by Neil MacCoull[19]. Of the 20 laboratories, at least half rely on the listening method, but it should be noted that in some laboratories this means detecting "incipient detonation" and that in others the attempt is made to distinguish between "light" and "moderate" detonation or between "moderate" and "heavy" knocking. Most of those who use the bouncing-pin probably will agree that the novice finds the bouncing-pin indicator as temperamental as the ear is indefinite. Nearly all the engines are water-cooled, but at least one laboratory reports that more satisfactory results are obtained with the air-cooled engine. There are only six L-head engines in the group, yet it chances that three of these are used at laboratories where the compression pressure, rather than the compression ratio, is varied to obtain audible detonation. The English laboratories supply heat electrically, at a constant rate of 1 kw. or more (57 B.t.u. per min.), to the air entering the carbureter, while more than half of the remaining laboratories maintain the carbureter air at some definite temperature above room temperature.

Survey of Fuels

The Bureau of Standards routine method for determining the relative antiknock value of motor fuels was fully described[20] at the last Annual Meeting of the Society. The high-compression single-cylinder Liberty engine shown in Fig. 7, coupled to an electric dynamometer, is operated at 1500 r.p.m. for a series of mixture-ratio runs with the spark set for maximum power in the absence of detonation, that is, at about 30-deg. advance. The throttle is initially adjusted so that, with the reference fuel, detonation is audible throughout most of the mixture-ratio range but is not excessive at any carbureter setting. Runs are made at this throttle setting, using air-fuel ratios ranging from full rich to full lean, and the maximum indicated horsepower obtained is termed the "maximum permissible power."

Similar runs are made at the same throttle-setting with the fuel under test, and the intensity of detonation is carefully noted. If there is less or more detonation with the test fuel, the throttle is adjusted until the detonation matches that obtained with the reference fuel and a third set of runs is made at the new throttle-setting. The maximum indicated horsepower developed by the test fuel at the final throttle-setting is compared with the maximum indicated horsepower developed by the reference fuel at the initial throttle-setting. Fuels are rated on a percentage basis in terms of maximum permissible power. Thus, if the reference fuel gave 25 hp. and the test fuel 30 hp., the knock ratings would be 100 for the reference fuel and 120 for the test fuel. Oil and water temperatures are maintained approximately constant, but the intake air is not heated. All ratings are preferably made as direct comparisons between two fuels. Such comparisons are ordinarily reproducible to within 1 or 2 per cent.

For use in the detonation survey, several refiners were asked last winter to submit samples of gasoline typical of current refinery production. Fifteen samples were received and these are listed in Table 2, where SR is used as an abbreviation for *straight run*, CR for *cracked*, and BlS for *blending stock*. Specific gravities and distillation data are presented for all samples except Nos. 1 and 2, which were used up without securing laboratory tests. Sample No. 16 was the Bureau of Standards reference-fuel and is therefore rated at 100.

TABLE 3—RATING OF REFINERY SAMPLES

Sample No.	Description[21]	Throttle	Knock Rating, Based on No. 16	Approximate Benzol Equivalent, Based on No. 16	Knock Rating, Based on No. 3	Approximate Benzol Equivalent, Based on No. 3
3	Pennsylvania, SR	2.0	89		100	0
14	Amarillo, SR	2.5	94		105.6	
9	Oklahoma, SR					
10	Ohio, SR	2.7	97.5		109.6	15
1	Salt Creek, SR	3.0	100	0	112.4	20
16	Commercial Refinery					
2	Salt Creek, CR	3.3	104	10	114.5	25
4	Commercial (Pa.)					
15	Amarillo, CR	3.5	110	20	123.6	35
5	Commercial (N. J.)	4.0	117	30	131.5	
6	Smackover, BlS					
12	Spindletop, SR	4.2	121	33	136.0	
8	Los Angeles, SR	4.6	125	37	140.5	
11	Los Angeles, SR	4.8	130	40	146.0	
7	Los Angeles, SR					
13	Spindletop, CR					

[21] SR indicates "straight-run"; CR, "cracked"; and BlS, "blending stock."

[18] See THE JOURNAL, January, 1928, p. 41.

[19] See p. 457.

[20] See THE JOURNAL, May, 1927, p. 599.

It will be noted that the refinery samples range from 11 per cent worse to 30 per cent better than this reference fuel.

In Table 3, the same 16 fuels are arranged in the order of their knock rating and there seems to be little difference in this respect between Nos. 9 and 14; between Nos. 1 and 10; between Nos. 2, 4 and 15; between Nos. 6 and 12; and between Nos. 8 and 11. Benzol equivalents based on No. 16 have been estimated as a matter of interest, but the available samples were not large enough to permit direct comparison with benzol blends. In the next to the last column are presented knock ratings based on the straight-run Pennsylvania sample, taken as 100. In the last column are estimated benzol equivalents indicating that 15 per cent of benzol blended with No. 3 would place it between Nos. 9 and 10; while 20 per cent would bring it nearly to No. 16. A 50-50 blend of No. 3 with benzol probably would not equal No. 7.

It was next decided to supplement this survey with a comparison of the average non-premium gasoline available to motorists in different sections of the Country. Samples which had been collected from filling-stations in a number of geographical districts were blended to give six composite samples. Only non-premium gasolines were included and the blend for each district was made up on the basis of the best available information as to the relative amounts of gasoline sold by leading oil companies in that district. The territory covered by each district, the make-up, and the name used to designate each sample, are as follows:

No. 1 represents Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, and is designated as the New England Sample

No. 2 represents the District of Columbia, Delaware, Maryland, New Jersey, New York, Pennsylvania, Virginia, West Virginia and North Carolina, and is designated as the New York Sample

No. 3 represents Illinois, Indiana, Michigan, Ohio and Kentucky, and is designated as the Chicago Sample

No. 4 represents Colorado, Iowa, Idaho, Minnesota, Montana, Nebraska, North Dakota, South Dakota and Wyoming, and is designated as the Denver Sample

TABLE 5—RATING OF COMPOSITE SAMPLES OF COMMERCIAL GASOLINE

Sample No.	Description	Throttle	Knock Rating
1	New England	2.6	84.3
2	New York	2.6	84.4
3	Chicago	2.4	82.3
4	Denver	2.5	83.4
5	California	3.6	97.4
6	Texas	2.7	86.4
7	Fuel X	4.2	105.1
8	Fuel Y	6.0	124.8
9	Reference, Bureau of Standards	3.8	100.0
10	No. 3 + Benzol	3.0	90.3

Sample No.	Description	Knock Rating	Approximate Benzol Equivalent, Per Cent
3	Chicago	100.0	
4	Denver	101.5	
1 & 2	New York & New England	103.0	10
6	Texas	105.0	15
10	Blend	109.7	20
5	California	118.4	30
9	Reference, Bureau of Standards	121.6	35
7	Fuel X	128.0	40
8	Fuel Y	151.9	50

Laboratory Data, Bureau of Standards

Sample No.	Specific Gravity, A.P.I. Deg.	Distillation Temperatures, Deg. Fahr. Initial Boiling-Point	20 Per Cent	50 Per Cent	90 Per Cent	Dry	Recovery, Per Cent
1	57.2	108	198	270	374	424	97.2
2	57.4	108	199	273	376	423	96.9
3	57.4	109	199	277	376	430	97.4
4	57.7	113	201	277	388	430	96.3
5	55.4	106	196	266	381	421	96.9
6	58.4	104	189	273	381	419	96.9
7	52.7	113	172	207	331	383	96.5
8	44.9	127	185	221	374	419	97.2
9	51.6	115	217	282	388	428	97.0

No. 5 represents Washington, Oregon, California, Nevada and Arizona, and is designated as the California Sample

No. 6 represents Texas only

Table 4 shows laboratory data on five of these samples furnished by The Texas Co.

Table 5 presents the Bureau of Standards laboratory data and knock ratings on the six composite fuels and three other fuels. Fuels Nos. 7 and 8 are commercial premium gasolines purchased in the open market in Washington and No. 9 is the reference fuel in use at the time these tests were made. This reference fuel, although rather poor in volatility, has a relatively high antiknock value, being nearly 20 per cent better than the reference fuel with which the refinery samples were

TABLE 4—LABORATORY DATA ON COMPOSITE SAMPLES FROM THE TEXAS CO.

Sample No.	1	2	3	4	6
Description	New England	New York	Chicago	Denver	Texas
Color, Saybolt	+6	+10	+16	+19	+14
Specific Gravity, A.P.I., deg.	54.7	57.3	57.4	58.2	57.5
Doctor Test	Negative	Negative	Negative	Negative	Negative
Unsaturation, per cent	7	6	8	6	8
Antiknock Value	0.75	0.75	Good	Good	Good
Copper-Strip Test	Good	Good	0.75	0.70	...
Distillation, per cent	Temperature, Deg. Fahr.				
Initial Boiling-Point	110	112	100	98	102
10	174	171	168	160	160
20	206	202	204	199	193
30	230	230	230	226	228
40	255	253	257	251	250
50	274	272	278	275	272
60	296	294	300	298	294
70	315	316	322	320	322
80	337	338	348	347	340
90	368	369	382	377	370
95	394	394	408	405	396
End-Point	420	417	426	422	410
Recovery, per cent	98.0	98.0	98.0	97.5	98.0
Residue, per cent	1.0	1.0	1.0	1.0	1.0
Loss, per cent	1.0	1.0	1.0	1.5	1.0

compared. It will be seen that the first four composite samples differ very little in knock rating. The Texas sample No. 6 is slightly better and the California sample No. 5 is considerably better but still not equal to No. 9. In the second section of Table 5 the samples have been arranged in the order of their knock rating and rated in terms of the Chicago district sample, No. 3, as 100. The benzol equivalents given here are estimated except for No. 10, which was prepared by blending No. 3 with 20 per cent of benzol.

APPENDIX

The Automobile Engineer presents distillation data and knock ratings[22] for 20 branded British motor fuels and a summary of these will be found in Table 6. The highest-useful-compression-ratio values were determined by Baron Van Wassenaer at the University of Cambridge, who used a Ricardo valve-in-head engine. The laboratory data were obtained by Dr. W. R. Ormandy. Knock ratings, that is, highest useful compression ratio, above 4.8 are considered *excellent;* those from 4.6 to 4.8, *good;* those from 4.4 to 4.6, *fair;* those from 4.2 to 4.4, *poor;* and those below 4.2, *bad.* It is pointed out by Whatmough[23] that all these values are somewhat below those which would have been obtained by Ricardo and Callendar for the same samples since, with the same model of engine, that is, E-35, Ricardo found 5.1 for Shell No. 1 petrol and Callendar, 5.4.

TABLE 6—MODERN BRITISH MOTOR FUELS

Sample Tested Petrols (No. 1):	Highest Useful Compression Ratio	Specific Gravity, A.P.I. Deg.	Distillation Temperatures, Deg. Fahr. Initial Boiling-Point	20 Per Cent	50 Per Cent	90 Per Cent	Dry
Red Line Super	5.05	61.7	102	176	234	329	358
Shell	4.76	62.5	100	171	239	351	379
Power	4.73	56.8	127	214	252	325	383
Pratts' Perfection	4.61	61.2	102	178	234	325	361
Glico	4.54	60.6	109	194	252	336	374
Russian Oil Products	4.52	55.0	162	225	259	331	396
British Petroleum	4.46	63.1	117	181	230	315	356
Blue Bird Private	4.39	61.9	111	192	244	331	378
Dominion	4.32	62.6	108	185	237	329	367
Standard Antiknock Petrols:							
Borneo: Old Straight Run	5.08	48.4	158	217	246	304	347
Borneo: New Straight Run	5.06	49.0	151	217	252	311	349
Antiknock Mixtures:							
Pratts' Ethylised Petrol	5.25 to 5.34	62.2	115	183	241	325	367
Red Line Benzole Mixture	5.14	54.7	108	189	239	351	383
Pratts' Benzole Mixture	4.98	52.8	115	181	219	322	367
National Benzole Mixture	4.88	51.3	127	185	223	338	390
Commercial Petrols:							
Red Line Commercial	5.03	57.8	95	199	262	363	383
Pratts' Gasoline	4.66	61.0	106	187	246	329	372
Mex. No. 3	4.63	59.2	104	189	248	342	388
Blue Bird No. 3	4.59	56.6	138	217	253	327	383
British Petroleum No. 3	4.46	59.6	117	189	241	333	379

TABLE 7—COMMERCIAL UNITED STATES MOTOR FUELS

Sample No.	Highest Useful Compression Ratio	Specific Gravity, A.P.I. Deg.	Distillation Temperatures, Deg. Fahr. Initial Boiling-Point	20 Per Cent	50 Per Cent	90 Per Cent	Dry
1	4.91	59.6	110	202	263	362	420
2	4.87	59.7	98	184	268	393	437
3	4.99	58.9	102	197	258	360	435
4	4.79	59.9	104	188	263	386	435
5	5.14	58.9	98	186	288	400	450
6	4.82	59.1	104	194	273	386	430
7	4.83	58.7	96	196	284	390	435
8	5.06	62.5	100	178	236	344	400
9	5.13	63.3	98	178	228	313	371
10	5.11	60.0	100	194	262	360	397
11	4.90	58.0	100	190	286	394	435
12	5.41	56.6	106	190	265	387	432
13	5.44	59.3	110	198	260	364	420
14	5.17	52.7	110	176	234	390	433
15	5.44	56.8	106	160	216	372	427
16	5.04	60.4	112	197	247	329	394
17	5.04	59.3	104	184	265	385	430
18	5.05	61.2	102	186	254	360	397
19	4.93	58.1	104	194	279	402	441
20	5.39	63.9	88	168	241	337	375

Table 7 presents knock ratings on 20 branded American gasolines purchased from filling-stations in the St. Louis district. These gasolines were rated at the laboratory of the Roxana Petroleum Corporation, where a Ricardo E-35 engine is used for routine fuel-testing. The values for highest useful compression ratio are always corrected at this laboratory so as to agree with Ricardo's rating on a common reference-fuel. The correction varies with engine condition from 1/5 to 4/5 of a compression ratio. The uncorrected values, which were in this case 0.44 lower, are probably more nearly comparable with those reported in Table 6. The brands, arranged in alphabetical order, were as shown in Table 8.

TABLE 8—HIGHEST USEFUL COMPRESSION RATIO

Below 5.00	5.00 to 5.25	Above 5.25
Lubrite	Benzol	Benzo
Pennant	Marland	Ethyl
Powerite	Marland, H. T.	Sinclair, H. C.
Red Crown	Shell	Super-Shell
Red Rose	Solite	
Sinclair	Sussex	
White Flash	Texas	
White Rose	Unique	

[22] See *The Automobile Engineer*, November, 1927, p. 452.

[23] See *The Automobile Engineer*, December, 1927, p. 487.

Methods of Measuring Detonation

By Neil Mac Coull[1]

A REPORT is made herein of an attempt to correlate measurements of the antiknock values of gasolines as determined by various laboratories. Six samples of gasoline were sent to each of 10 laboratories that agreed to cooperate, the principal object being to learn whether volatility affects the antiknock values obtained from multi-cylinder engines more than it affects the values obtained from single-cylinder engines. The results of the tests are shown in numerous tables and charts.

The conclusions reached are that

(1) Further development of antiknock measurements is needed

(2) Certain elements of technique, such as the mixture-ratio and the spark-setting should be standardized at once

(3) Intensive study should be made of the fundamental methods in use for the direct control of detonation in test engines, such as the compression ratio and the manifold vacuum

(4) Measurement of antiknock values in terms of the mixtures of a reference fuel with

[1] M.S.A.E.—Automotive engineer with research duties, The Texas Co., New York City.

benzol or tetraethyl lead is likely to be very misleading if the peculiarities of such scales are not thoroughly understood by the investigator

(5) The data obtained indicate that probably no great difference in the results exists whether the detonation point is determined by durability, the maximum power, or the bouncing-pin

(6) The size and type of engine used does not seem to affect the results

(7) Eventually, a reference fuel of low antiknock value and one of high antiknock value should be standardized

AN investigation has been made of the possibility of correlating the measurements of the antiknock values of gasolines determined by various laboratories. With this end in view, six samples of gasoline were sent to each laboratory that expressed its willingness to cooperate in the investigation. These laboratories included those listed below, the number in parentheses in each case indicating the identifying number used in the text and tables:

(1) Anglo-Persian Oil Co., London
(2) Kansas City Testing Laboratory, Kansas City, Mo.
(3) University of Michigan, Ann Arbor, Mich.
(4) Atlantic Refining Co., Philadelphia
(5) Standard Oil Co. of Indiana, Whiting, Ind.
(6) The Texas Co., Bayonne, N. J.
(7) Bureau of Standards, City of Washington
(8) Chrysler Corporation, Detroit
(9) Tide Water Oil Co., Bayonne, N. J.
(10) Mellon Institute, Pittsburgh

The six gasolines used had a wide range of antiknock values and volatility. We desired particularly to learn whether volatility affected the antiknock values determined on multi-cylinder engines more than those determined on single-cylinder engines. In Table 1 are shown the results of the tests, together with a measure of the volatility of the gasolines as expressed by their mean boiling-points.

The Apparatus and Methods of Testing Used

An analysis of the main features of the apparatus and the methods of testing used by the cooperating laboratories is shown in Table 2. In spite of the apparently heterogeneous nature of the data, one point that they have in common may prove to be the fundamental point necessary to produce interchangeable antiknock values, namely, the method of controlling detonation by varying the compression pressure. Mechanically, this is accomplished in two ways, (*a*) altering the volume of the combustion space that controls the compression-ratio, as in so-called variable-compression engines, or (*b*) altering the initial pressure with the throttle, as in engines having a fixed compression-ratio.

The design and the size of the combustion-chamber greatly affect detonation, as Ricardo has again shown in a recent address, in which he stated that he had changed the compression-ratio at which knocking in an engine begins, from 5.2 to 6.0, simply by moving the position of the spark-plug.

Whether such a feature of design will offer difficulty in correlating antiknock data is still to be proved, very

TABLE 1—ANALYSES OF SIX TEST-FUELS USED IN THIS INVESTIGATION

	Test Fuel					
	AK Petroleum Spirits	*BK* 3.4 Cc. of Ethyl Fluid per Gal. of AK	*CK* 50 Per Cent of 90 Per Cent Benzol and 50 Per Cent of AK	*DK* Gasoline	*EK* Gasoline	*FK* Gasoline
Color, Saybolt	+25	Red	+20	+25	+21	+18
Gravity, A. P. I.	49.5	49.0	40.1	58.4	60.2	52.9
Doctor Test	Negative	Negative	Negative	Positive	Negative	Negative
Copper Dish Corrosion	Good	Good	Good	Good	Good	Good
Copper Strip Corrosion	Good	Good	Good	Good	Good	Good
Bureau of Mines Gumming	None	None	None	None	None	None
Distillation	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.	Deg. Fahr.
Initial Boiling-Point	290	293	176	120	92	100
10 Per Cent	320	317	187	202	146	144
20	326	326	195	228	180	182
30	332	330	213	246	211	214
40	339	338	218	260	239	240
50	345	345	248	274	265	262
60	352	352	306	292	285	282
70	361	362	338	309	306	306
80	372	375	356	330	328	330
90	393	392	378	365	356	356
95	410	409	398	399	380	380
End-Point	436	436	420	436	392	390
Recovery, per cent	98.5	98.5	98.0	98.5	97.5	97.5
Residue, per cent	1.0	1.0	1.0	1.0	1.0	1.0
Loss, per cent	0.5	0.5	1.0	0.5	1.5	1.5
Mean Boiling-Point, deg. fahr.	357	356	286	289	265	266

TABLE 2—CHARACTERISTICS OF APPARATUS AND METHODS OF TESTING

Laboratory Number Laboratory Name	1 Anglo-Persian Oil Co.	2 Kansas City Testing Laboratory	3 University of Michigan	4 Atlantic Refining Co.	5 Standard Oil Co. of Indiana	6 The Texas Co.		7 Bureau of Standards	8 Chrysler Corporation	9 Tide Water Oil Co.	10 Mellon Institute
						A	*B*				
Shape of Combustion Chamber	I	L	I	L	L	L	I	I	I	I	I
Number of Cylinders	1	1	1	1	1	4	1	1	1	1	1
Bore and Stroke, in.	3½x6	5x6	5x7	2⅞x4	2⅞x4	4½x6¼	5x6	5x7	2½x5	2½x5	2½x5
Speed, r.p.m.	1200	500	1000	1200	1200	400	400	1500	1000	1000	1000
Valves per Cylinder	4	2	4	2	2	2	2	2	2	2	2
Compression-Ratio	3.9 to 8	3 to 9	3 to 17	6.5	5.6	4.7	6.3	6.3	7.6	7.4	5.5
Carburetor - Air Temperature, deg. fahr., Mixture-Ratio	100 Fuel Rate Adjusted to 7.7 Lb. per Hr.	70-80 Non-Adjustable	150 13.1	140 Set at 12 to 1 for Reference Fuel	120-125 11 to 1	210 Non-Adjustable	Room 13 to 1	Room Varied for Maximum Power	Room Non-Adjustable	Room Vary for Maximum Detonation of Unknown Fuel	131
Spark Advance, deg.	40, 40½, 45	30	15, 25	25	21	30	20	30	.....	Maximum Power	25
Controlled by	Compression	Compression	Compression	Throttle	Throttle	Throttle	Throttle	Throttle	Throttle	Throttle	Throttle
Method Used	Audibility	Audibility	(*a*) Audibility (*b*) Maximum Power	Audibility	Audibility	Audibility	Audibility	Audibility	Bouncing-Pin	Bouncing-Pin	Special Bouncing-Pin
Results in terms of	Difference of Compression-Ratio	Compression-Ratio and Benzol	Compression-Ratio and Benzol	(Manifold Vacuum) Benzol, Tetraethyl Lead	Ethyl Fluid	(Manifold Vacuum) Ethyl Fluid	Manifold Vacuum	Indicated Horsepower Increase, Per Cent	Ethyl Fluid	Special Numbered Benzol Blends	Benzol or Iso-Amyl-Nitrite
Reference Fuel	A Definite Refinery Cut Gasoline	Straight-Run Gasoline Having Minimum Anti-Detonating Value	Straight-Run Pennsylvania Federal Specification Fuel	Straight-Run Mid-Continent Gasoline of United States Specification	Straight-Run Mid-Continent Gasoline, Slightly Better than United States Motor Specification	Petroleum Spirits	Straight-Run Pennsylvania Gas of 400 End-Point	(*a*) United States Motor No. 12 (*b*) Cabin Creek Gasoline	Ethyl Gasoline Laboratory Standard Anti-Knock Fuel	Standard Straight-Run Pennsylvania Gasoline	Straight-Run Gasoline from Mixed Average Oklahoma-North Texas Crude

few data in this investigation being of value on this angle of the subject because of the variation of the technique of operating the engines. For reference, the designs of several of the combustion-chambers of engines used in the tests by the cooperating laboratories are shown in Fig. 1. They are approximately to scale in order to indicate their variation in size.

The methods used in operating the engines may be clarified by dividing the test procedure into the following steps:

(1) An engine that can be made to detonate must be used

(2) The engine must be under control from the non-detonating to the detonating range. This is accomplished by varying the final compression-pressure by (*a*) altering the volume of the compression space while holding the throttle fixed, or (*b*) altering the initial compression-pressure by the throttle

(3) Detection of the detonation-point by (*a*) audibility, which may be of light or of heavy intensity, (*b*) the bouncing-pin, or (*c*) the maximum efficiency as determined by the maximum power output and the measurement of waste heat, by taking the temperature of the exhaust-valve, the jacket loss, and the like

(4) Evaluation of results in terms of (*a*) the increase of the compression-ratio allowable, the power output, or the manifold vacuum, (*b*) an equivalent antiknock fuel made by mixing some reference fuel of low antiknock value, such as Pennsylvania gasoline, with tetraethyl lead, isoamyl nitrite (a knock inducer), or benzol, (*c*) the addition of tetraethyl lead to the fuel being tested, to equal a reference fuel of high antiknock value

This outline does not, of course, exhaust the possibilities, but covers the majority of the methods now in use.

Before leaving the description of test methods, attention is called to the novel method used by Laboratory 1 for the detection of the detonation-point, since this method is not well known in this Country.

With a standard reference-fuel, the compression-ratio is raised until the first detonation is audible. A reading is then taken of the number of knocks or "pinks" per minute. The ratio is then raised 0.1 and another esti-

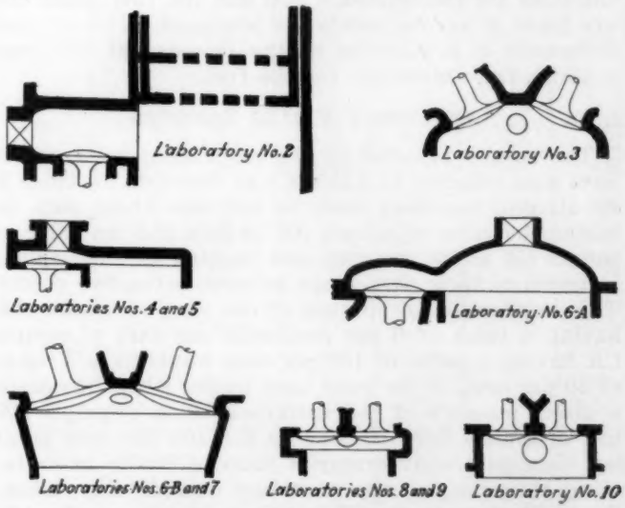


FIG. 1—TYPES OF COMBUSTION-CHAMBER DESIGN

These Combustion-Chambers, Used in Tests by the Cooperating Laboratories, Have Been Drawn Approximately to Scale To Indicate Their Variation in Size

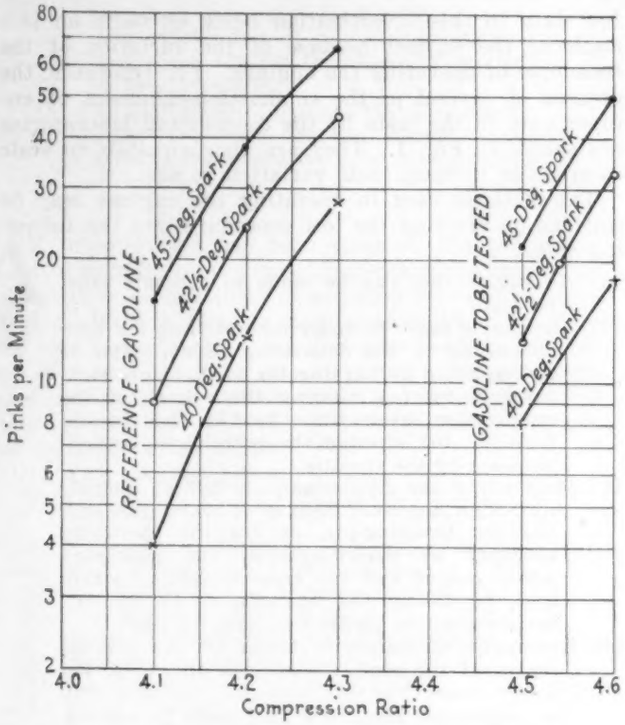


FIG. 2—NOVEL METHOD USED BY LABORATORY

The Data Are Reported in Terms of Increase of Compression-Ratio, between an Unknown Fuel and a Reference Fuel. This Difference Is Taken as the Average Distance between the Times Plotted for Both Fuels and Showing the Intensity of Detonation by the Number of "Pinks" per Minute at Various Compression-Ratios. Results Are Averaged for Several Spark Positions

mate is made of the number of knocks per minute. One more rise of 0.1 of a compression is made, and the data are plotted as in Fig. 2, the scale of knocks per minute being logarithmic to straighten the line. This is done for three different spark-advances, namely, 40, 42.5 and 45 deg. The engine is thus calibrated and is ready for the fuel to be tested. This fuel is treated in the same way and gives the curves shown at the right of Fig. 2. The horizontal distances between corresponding lines for the reference fuel and the fuel under test are taken at several points and averaged. This average difference is a measure of the increase of the compression-ratio allowable for the fuel.

ANTIKNOCK VALUES REPORTED

The results reported by the cooperating laboratories have been collected in Table 3. At the right of Table 3, an attempt has been made to correlate these data by taking the value of sample *AK* as zero and the value of sample *CK* as 100 per cent, and locating all other values in terms of their percentage between these two points. This implies that a mixture of one part of sample *AK* having a value of 0 per cent with one part of sample *CK* having a value of 100 per cent would have a value of 50 per cent, if the basis used by the laboratory were a direct measure of the antiknock value. Sample *FK* had originally been planned as the 100 per cent point but since several laboratories found difficulty in evaluating this sample, the next best sample was taken. Furthermore, sample *CK* is the same as sample *AK*, except for the addition of 50 per cent of benzol; and most laboratories gave a benzol equivalent to their readings.

At the bottom of Table 3, the averages of the values reported by all laboratories are shown. The great variation given by these laboratories warrants a detailed analysis. One means of doing this was to group together all readings taken for each type of antiknock scale.

BENZOL EQUIVALENTS

In Table 4 the benzol values are retabulated from Table 3. The column showing the differences between the highest and the lowest values reported for each sample indicates that the greatest variation is in sample *AK* and the least in sample *BK*.

TABLE 4—BENZOL EQUIVALENTS OF VARIOUS SAMPLES OF GASOLINE IN PER CENT

	Laboratory Symbol							Difference	Average	Relative Percentage
	2	3	4	6	7	9	10			
AK	−24	−25	−34	−12	0	(−7.5)−23[b]	....	34	−20	0
BK	24	27	29	33	25	(45) 30[b]	25	9	28	86
CK	27	45	36	36	35–40	(53) 38[b]	33	18	36	100
DK	− 6	5	11	0	0	(15) 0[b]	....	16	− 2	32
EK	36	28	25	28	30	(40) 25[b]	23	13	28	86
FK	45[a]	62.5	59	....	50+	(75) 60[b]	50+	35	61	145

[a] Values for mixtures having an equal volume of reference fuel.
[b] Corrected values.

We had expected that all the values reported by some laboratories would be higher than those by some other laboratories, because of the different antiknock values of the stocks of gasoline used as reference fuels. The location of the points for each laboratory, given in Fig. 3, shows that none is consistently higher or lower than the others, except Laboratory 9. In making up the averages, the liberty was taken of subtracting 15 from all the readings shown by this laboratory. The justification for this procedure is shown in Fig. 3. The dotted line shows the uncorrected values. The variation between these readings and those from all the other laboratories seems to be caused more by errors of observation than by differences in the reference fuels used. An average of all the benzol equivalents was considered to give a good indication of the true value for each sample.

Sample *CK* was made up of *AK* and 50 per cent of benzol. If the average value of *AK*, 20 per cent, be subtracted from that of *CK*, 36 per cent, this would account for 56 per cent of benzol, which is not far off. Sample *DK*, a Pennsylvania gasoline, had nearly the same antiknock value as the reference samples used by other laboratories.

EFFECT OF VOLATILITY

The values from Table 4 were plotted in Fig. 3 against the benzol values obtained with the four-cylinder engine of Laboratory 6-*A*. The averages from all the laboratories are indicated by large crosses that fall with remarkable consistency on the straight line shown, excepting samples *AK* and *BK*. To make the points for these two samples fall on the same line, they would have to be moved to the left a distance equivalent to about 5 per cent of benzol, giving *AK* a value of —17 per cent and *BK* a value of 28 per cent. In other words, the values of these two samples given by Laboratory 6-*A*, which control the horizontal positions of all points, seem to be too high. This is believed to be evidence of the

TABLE 3—RESULTS REPORTED BY COOPERATING LABORATORIES

	Reported Values						Comparative Values ($AK=0$ and $CK=100$ Per Cent)			
	AK	*BK*	*CK*	*DK*	*EK*	*FK*	*BK*	*DK*	*EK*	*FK*
1—*Anglo-Persian Oil Co.*										
Increase of Compression Ratio:										
Observer *A*	−0.29	0.24	0.61	−0.15	0.22	1.34	59	15.5	57	181
Observer *B*	−0.29	0.25	0.57	−0.17	0.24	1.28	63	14.0	62	183
2—*Kansas City Testing Laboratory*										
Benzol Equivalent	−24	24	27	−6	36	45[c]	94	20	137	
Compression Ratio	3.16	3.72	3.74	3.37	3.85	3.95[c]	97	36	144	
Increase in Compression Ratio, per cent	−9.1	8.1	8.7	−2.1	11.9	14.8[c]	96	36	119	
Power, watts	440	456	473	425	437	465[c]				
Power Increase, per cent	3.1	6.8	10.8	−0.5	2.3	8.9[c]	48	−47	−10	
3—*University of Michigan*										
Compression Ratio:										
Audible Knock:										
25-Deg. Spark Advance	4.35	4.9	5.22	4.65	4.88	5.95	63	34	62	184
15-Deg. Spark Advance	4.91	5.44	5.50	5.10	5.40	6.45	90	32	83	260
Maximum Power:										
25-Deg. Spark Advance	4.5	5.1	5.47	4.92	5.15	6.15	62	43	67	170
15-Deg. Spark Advance	5.15	5.73	6.12	5.40	5.85	6.76	60	26	72	166
Benzol Value with Pennsylvania Gasoline:										
Audible Knock:										
25-Deg. Spark Advance	−20	25	44	10	25	60	70	47	70	125
15-Deg. Spark Advance	−20	30	32	0	22	65	96	38	81	163
Maximum Power:										
25-Deg. Spark Advance	−25	25	45	10	28	62	71	50	76	124
15-Deg. Spark Advance	−30	28	45	0	33	63	77	40	84	124
Average	−25	27	45	5	28	62.5	74	43	76	125
4—*Atlantic Refining Co.*										
Manifold Vacuum, in. of mercury	4.37	3.7	3.6	4.1	3.75	3.15				
Benzol, per cent	0	37	40	21	36	56	92	52	90	140
	−34	29	36	−11	25	59	90	33	84	133
Tetraethyl Lead per Gallon, cc.	0	2.7	3.1	1.1	2.5	8.0	87	35	80	258
	−2.3	1.7	2.5	−0.5	1.4	9.5	83	37	77	246
5—*Standard Oil Co of Indiana*										
Tetraethyl Lead per Gallon, cc.	3.6	1.0	0	2.1	0.6		72	42	83	
	−2.1	0.5	1.5	−0.6	0.9	4.6?	72	42	83	186
6—*The Texas Co.*										
(*A*) Four-Cylinder Engine:										
Manifold Vacuum, cm. of mercury	36.3	30.4	30.5	35.5	31.5					
Power, b. hp.	5.7	7.4	7.3	5.9	7.0					
Equivalent Ethyl Fluid per Liter cc.	0	1.6	1.9	0.25	1.35		84	13	71	
Benzol, per cent in Pennsylvania gasoline	−12	33	36	0	28		94	25	83	
(*B*) Single-Cylinder Engine:										
Manifold Vacuum, cm.	35.9	31.3	31.2	34.7	32.1	27.3	98	27	81	185
Benzol Equivalent, per cent	34.2	29.9	29.6	33.1	30.5	25.6	92	22	77	215
7—*Bureau of Standards*										
U. S. Motor Fuel No. 12:										
Power Increase, per cent of i. hp.	−23.5	−13	−5.5	−23.5	−10	25	58	0	75	270
Benzol Equivalent, per cent.[1]						40				
Ethyl Fluid per Gallon, cc.[1]						7				
Cabin Creek Reference Fuel:										
Power Increase, per cent of i. hp.	0	13.5	23.5	0	17.5	63	57	0	74	268
Benzol Equivalent, per cent[1]	0	25	35-40	0	30	50+	67	0	80	133
Ethyl Fluid per Gallon, cc.[1]	0	2-3	6	0	3-4	30	33-50	0	50-67	500
8—*Chrysler Corporation*										
Ethyl Fluid, cc. per gal. Relat., to FK	14.4	11.4	1.2	6.4	2.0	0	23	66	94	109
Ethyl Fluid, cc. per gal. Std. Rating	14.0	11.0	0.8	6.0	1.6	−0.4				
9—*Tide Water Oil Co.*										
Scale No.	16.5	6.0	4.5	12.0	7.0	0	87	37	79	137
Benzol Equivalent, per cent	7.5	45	52.5	15	40	75				
10—*Mellon Institute*										
Benzol Equivalent, per cent	....	25	33	....	23	50+				
Isoamyl Nitrite, per cent	0.35	....	....	0.07						
Rating, per cent:										
Benzol Basis	0	52.4	59	19.7	50.8	100	89	33	86	170
Isoamyl Nitrite Basis	0	42.2	51.6	7.8	39.1	100	82	15	76	194
Range										
Maximum							97	66	144	500
Minimum							23	−47	−10	109
Average							74	30	80	190

[c] Values for mixture with an equal volume of reference fuel.
[1] Estimated.

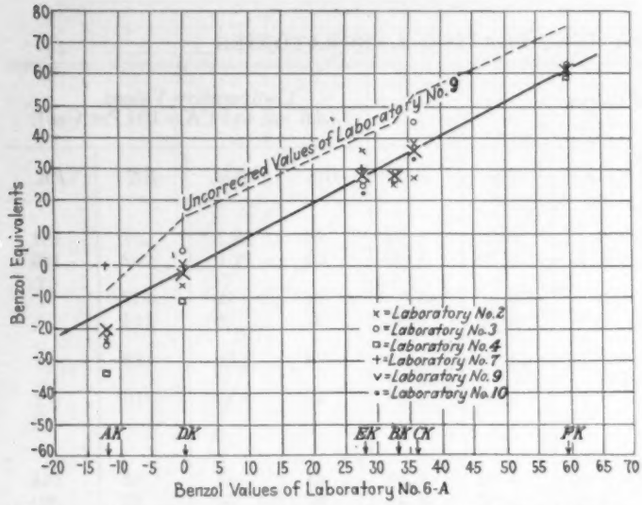


FIG. 3—CURVES SHOWING COMPARATIVE BENZOL VALUES OBTAINED BY THE VARIOUS LABORATORIES, PLOTTED AGAINST THE VALUES OBTAINED FROM THE FOUR-CYLINDER ENGINE OF LABORATORY 6-A

The Average for Each Reference Fuel Is Shown by a Large *X*. These Averages Fall in a Straight Line Except for Fuels *AK* and *DK*. These, Being of Lower Volatility Than the Others, Indicate the Effect of Volatility on Antiknock Rating in Multi-Cylinder Engines

effect of volatility, for these two samples are the only ones that have appreciably lower volatility than the others. In single-cylinder engines, the volatility would be expected to have but little effect, but in multiple-cylinder engines the story is different because of the likelihood of uneven fuel-distribution.

Laboratory 6, the only one that uses a multiple-cylinder engine, is therefore most likely to show the effect of volatility. It is evident that uneven distribution of fuel to the cylinders will reduce the apparent tendency of a fuel to knock, because of the well-known fact that the correct mixture will knock more than one that is either leaner or richer. Thus, a fuel of low volatility might be given a higher antiknock value in a multiple-cylinder engine than it should really have, as apparently happened in samples *AK* and *BK*. This characteristic of a multiple-cylinder engine should not be dismissed without noting that almost all fuels of today are used in multiple-cylinder automobile engines, in which volatility has an effect on the antiknock value similar to that in the engine now used in Laboratory 6-*A*.

TETRAETHYL LEAD EQUIVALENTS

In Table 5 are shown the values taken from Table 3, which were reported by laboratories that gave their data in terms of tetraethyl lead.

TABLE 5—TETRAETHYL-LEAD EQUIVALENTS IN CUBIC CENTIMETERS PER GALLON

	Laboratory Symbol					Difference	Average	Relative Percentage
	4	5	6	7	8			
AK	0 (−2.3)	0 (−2.1)	0	0	(0)	0	0	0
BK	2.7 (1.7)	2.6 (0.5)	3.3	1.3	(3.0)	2.0	2.46	74
CK	3.1 (2.5)	3.6 (1.5)	3.7	3.0	(13.2)	0.7	3.35	100
DK	1.1 (−0.5)	1.5 (−0.6)	0.5	0	(8.0)	1.5	0.8	24
EK	2.5 (1.4)	3.0 (0.9)	2.7	1.8	(12.4)	1.2	2.49	75
FK	8.0 (9.5)	... (4.6?)	11.8	15.0	(14.4)	7.0	11.60	347

The values shown for Laboratories 5 and 8 are not the same as those given in Table 3. Laboratory 5 originally reported the amount of tetraethyl lead that must be added to all samples to equal *CK*, and Laboratory 8 reported the amount to equal *FK*. To make the data of Table 4 comparative, the liberty was taken of attempting a conversion by subtracting all values of Laboratory 5 (first column) from 3.6 and by subtracting those of Laboratory 7 from 14.4. The converted figures of Laboratory 8 look so erratic that they have been omitted when computing the Difference and Average columns. The data of Laboratory 6-*A* have been multiplied by 1.97 to convert the readings of ethyl fluid from cubic centimeters per liter into cubic centimeters per gal.

An unexpected point was brought out by Laboratories 4 and 5, since each reported two sets of values. In one set, the values of all samples were compared with sample *AK*, and in the other set with their own reference-fuel. These two sets of figures for Laboratory 5 show a constant difference of 1.5 for all samples, indicating that one was calculated from the other. Laboratory 4, stating that this is an unjustifiable procedure, gives values that show a progressive difference from −2.3 for *AK*, to +1.5 for *FK*.

PERCENTAGE OF POWER INCREASE

Table 6 shows the percentage of increased power developed by various samples of gasoline over that which could be secured from sample *AK*. The variations are even greater than those obtained by other methods.

TABLE 6—PERCENTAGE OF POWER INCREASE BASED ON AUDIBLE DETONATION

	Laboratory Symbol		
	2	6-A	7
AK	0	0	0
BK	3.7	30.0	13.5
CK	7.7	28.0	23.5
DK	3.5	4.0	0
EK	0.7	23.0	17.6
FK	?	...	63.4

If the friction and other power losses of these engines were known, so that the indicated, instead of the brake or the electrical, horsepower could be used in all instances, this method might be more consistent than it seems to be in this table. The data from Laboratories 2 and 6-*A* are given in terms of power output, only Laboratory 7 reporting in terms of indicated horsepower.

COMPRESSION-RATIO

Some of the most interesting and important material developed in this investigation has been secured from the three laboratories using variable-compression engines. The fundamental value of data secured from variable-compression engines is due to the fact that the prime interest in the antiknock value of fuels is assumed to lie in the compression-ratios that can be used in engines to which they are supplied. Another very inviting feature of these engines is that they make possible antiknock determinations on the basis of the compression-ratio giving the maximum power. Such determinations do not involve the personal element of the operator's ear, as all audibility methods do. Fig. 5, supplied by Laboratory 3, shows how sharply defined

the point is for the compression-ratio giving the maximum power.

Attention has been called to the expectation that data from variable-compression engines might be directly comparable with manifold-vacuum figures from fixed-compression engines. For this reason, part (*a*) of Table 7 shows all the variable-compression and manifold-vacuum figures that were reported. The actual compression-ratios for Laboratory 1 were computed from Table 3 by adding 4.1. This value was taken from Fig. 2 and was considered as the point at which an operator might record the first "audible detonation." How the intensity of detonation recognized by the operator might affect the actual compression-ratio that he would report is apparent.

The compression-ratios for maximum power average about 0.3 of a ratio above the compression-ratios selected by audibility. The intensity selected by an operator must affect this difference, but apparently a simple relation exists between these two methods even though they are so different in principle.

In part (*b*) of Table 7 are shown the percentages of increase of all samples, compared to *AK*, for the compression-ratio and manifold-vacuum data. In each case the larger value was divided by the smaller, and 100 was then subtracted to show the percentage of increase.

Table 8 compares the average values obtained from each of the three methods used in Table 7. The agreement is more satisfactory than was hoped for.

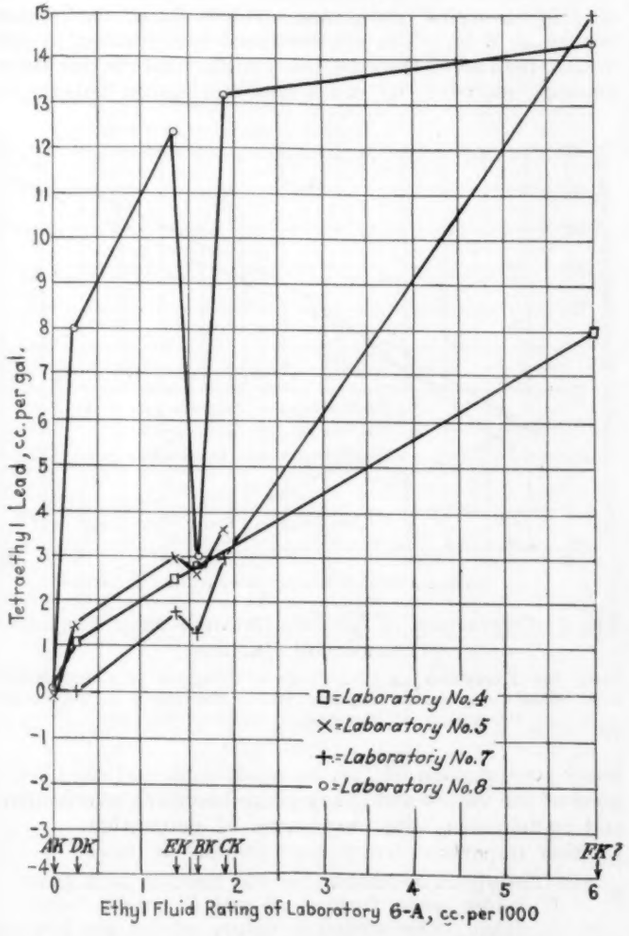


FIG. 4—CURVES OF THE COMPARATIVE VALUES OF TETRAETHYL LEAD OBTAINED BY THE VARIOUS LABORATORIES, PLOTTED AGAINST THOSE OBTAINED BY LABORATORY 6-A

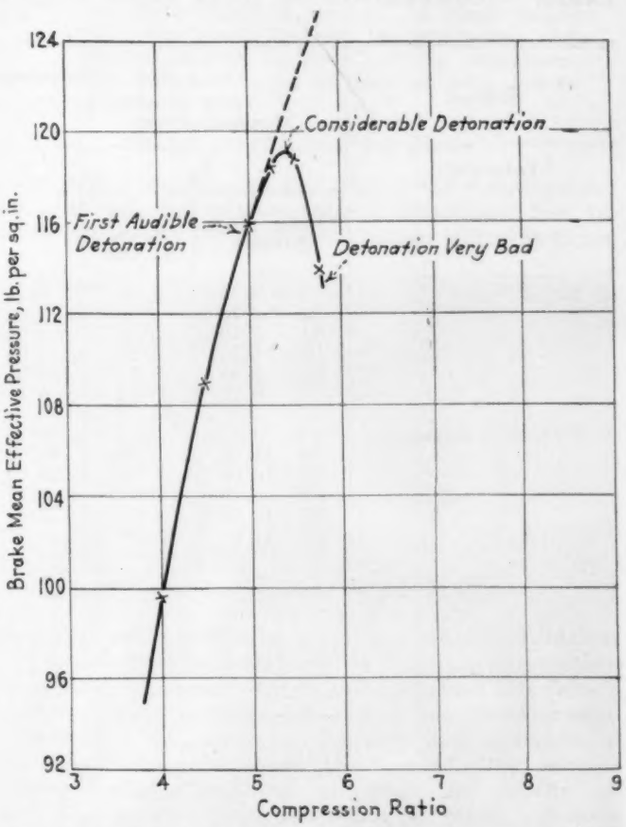


FIG. 5—CURVE SHOWING SHARP DEFINITION OF THE DETONATION POINT AS DETERMINED BY THE COMPRESSION-RATIO GIVING MAXIMUM POWER

The exceptionally satisfactory agreement among these three methods is noteworthy. Not only is there no appreciable difference between the variable and the fixed-compression engines but the results obtained by the audibility method were similar to those taken at maximum power. To show clearly the similarity of the data from various laboratories, the percentage figures from the single-cylinder engine of Laboratory 6-*B* are plotted horizontally in Fig. 6, the corresponding readings from Laboratory 4 and the multi-cylinder engine *B* of Laboratory 6 being plotted as ordinates. The agreement is very good. Another set of readings is also given in which the averages from each of the two variable-compression engines have been plotted as ordinates. This still further accentuates the agreement. This figure does not substantiate the evidence of the effect of low volatility that was shown in Fig. 3, though sample *BK* still shows a tendency to irregularity.

Since Laboratories 2 and 3 both gave benzol equivalents for their compression-ratios, these relations have been plotted in Fig. 7. For Laboratory 1, benzol values were assumed as the average values shown in Table 4. The similarity of the curves obtained by Laboratory 3 for the values taken for audible detonation and for maximum power recalls the close relation between these two methods that has been mentioned.

From Fig. 7 and Fig. 12, which will be referred to later, the relation between the compression-ratio and the manifold-vacuum was plotted, in Fig. 8, for various benzol blends in sample DK, thus comparing data from

TABLE 7—COMPARISON OF DATA FROM VARIABLE-COMPRESSION AND FROM FIXED-COMPRESSION ENGINES

Method	Compression-Ratio						Manifold Vacuum		
	Maximum Power		Audible Detonation				Audible Detonation		
Laboratory	3		1	2	3		4	6	
	15-Deg. Spark Advance	25-Deg. Spark Advance			15-Deg. Spark Advance	25-Deg. Spark Advance		*A*	*B*
(*a*) Actual Values	*AK* 5.15	4.50	3.81	3.16	4.91	4.35	4.37	36.30	34.20
	BK 5.73	5.10	4.34	3.72	5.44	4.90	3.70	30.40	29.90
	CK 6.12	5.47	4.69	3.74	5.50	5.22	3.60	30.50	29.60
	DK 5.40	4.92	3.94	3.37	5.10	4.65	4.10	35.50	33.10
	EK 5.85	5.15	4.31	3.85	5.40	4.88	3.75	31.50	30.50
	FK 6.76	6.15	5.41	3.95[d]	6.45	5.95	3.15	....	25.60
(*b*) Per Cent of Increase	*AK* 0	0	0	0	0	0	0	0	0
	BK 11.50	13.50	14.00	17.50	11.00	12.50	18.00	19.00	14.50
	CK 19.00	21.50	23.00	18.50	12.00	20.00	21.00	19.00	15.50
	DK 5.00	9.00	3.30	6.50	4.00	7.00	6.50	2.00	4.00
	EK 13.50	14.50	13.00	22.00	10.00	12.00	16.50	15.00	12.00
	FK 31.00	36.50	42.00	25.00[d]	31.00	37.00	39.00	....	34.00

[d]Values for mixture with an equal volume of reference fuel.

variable-compression engines with those from a fixed-compression engine. The remarkable straightness of the lines is still more evidence of the close relation between these methods, and gives encouragement to this attempt to correlate data obtained from variable-compression engines with those from fixed-compression engines, by either the audibility or the maximum-power method. There is no fundamental difference in the action of the gases. In the variable-compression engine, a fixed volume of combustible mixture is drawn into the cylinder and the compression-ratio is varied by changing the volume of the compression space. In the fixed-compression engine, the volume of the compression space being constant, the ratio is altered by changing the volume of the mixture entering the cylinder at atmospheric pressure. Measurement of this volume may be made by any convenient means. Laboratory 6-*B* uses a gas-holder, but finds it simpler to record the manifold vacuum, since a direct relation exists between the vacuum and the volume of the air supply per revolution, as well as the compression-pressure.

One more point of interest in the data of group (*a*) of Table 7 is the considerable variation in the compression-ratio allowable for any one fuel sample in the different engines used. This shows clearly the impossibility of stating that a given fuel could be used in an engine having a particular compression-ratio without at the same time specifying the engine.

Some data bearing on the subject of antiknock measurement have been secured from a single-cylinder engine that has been in operation in our laboratory for several months. The principal features of the set-up are shown in Fig. 9. The engine consists of a standard steel Liberty airplane-engine cylinder mounted on a marine-engine crankcase, which fixed the piston stroke at 6 in. The engine speed was limited to 400 r.p.m., instead of the customary higher speeds, for three reasons, namely, (*a*) much less mechanical noise, (*b*) lower consumption of fuel on a test and (*c*) less likelihood of the valves and spark-plugs becoming overheated and complicating the phenomena of detonation.

TABLE 8—AVERAGES OF EACH METHOD OF TABLE 7

	Compression-Ratio for Maximum Power	Compression-Ratio for Audible Detonation	Manifold Vacuum for Audible Detonation	Grand Average	Percentage Rating
AK	0	0	0	0	0
BK	13	14	17	14.7	77
CK	20	18	19	19.0	100
DK	7	5	4	5.3	28
EK	14	14	15	14.3	75
FK	34	37	37	36.0	190

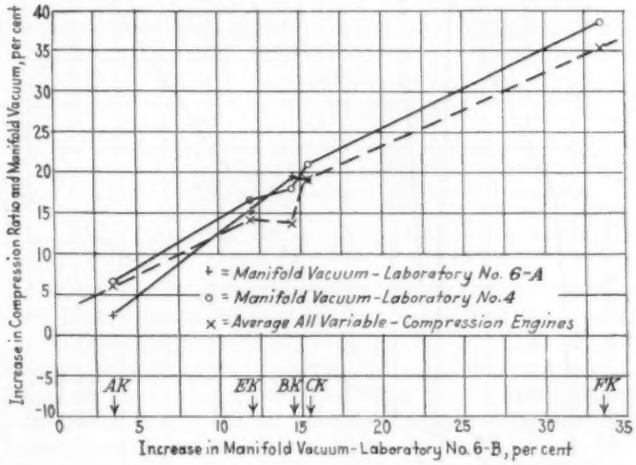


FIG. 6—COMPARISON OF RESULTS OBTAINED FROM VARIABLE-COMPRESSION ENGINES

They Are Expressed as Percentage of Increase of Compression with Fixed-Compression Engines When Expressed in Terms of Percentage of Increase of Manifold Vacuum

Other important features of this set-up were:

(1) The air to the carbureter was metered by a gas-holder made from a 55 and a 100-gal. steel drum. The pulsating nature of the air flow necessitated suspending the movable drum by a coiled spring. Electrical contacts closed by

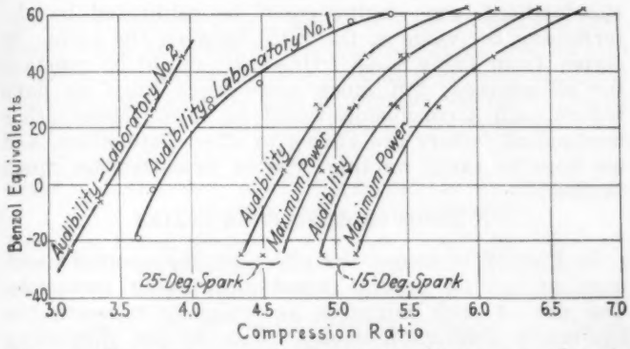


FIG. 7—RELATION OF COMPRESSION-RATIO TO BENZOL EQUIVALENT REPORTED BY LABORATORIES 1, 2 AND 3

The Four Curves on the Right Are for Laboratory 3, Whose Report Includes Several Methods of Detecting Detonation

the movement of the drum operated a stop-watch and a revolution-counter

(2) A horizontal Stromberg carbureter was provided with a very fine needle-adjustment giving 100 notches to 1 turn

(3) The engine was connected to a 10-kw. shunt-wound motor, which "floats" on the line and maintains a fairly constant speed at any throttle position. Even during the period in which the fuel is drained from the carbureter, the drop in speed is only small. This eliminates much of the time normally used in starting and regulating a dynamometer, unless a double carbureter is provided

(4) A steam cooling-system was used, which shortens the warming-up period and maintains a constant cylinder-head temperature without manual or thermostatic control

(5) The detonation-point, determined by ear, was recorded by manifold vacuum. A 5-gal. surge-tank was placed between the intake-pipe and the manometer to damp out the pulsations. The fluid used in the manometer had a specific gravity of 2.04

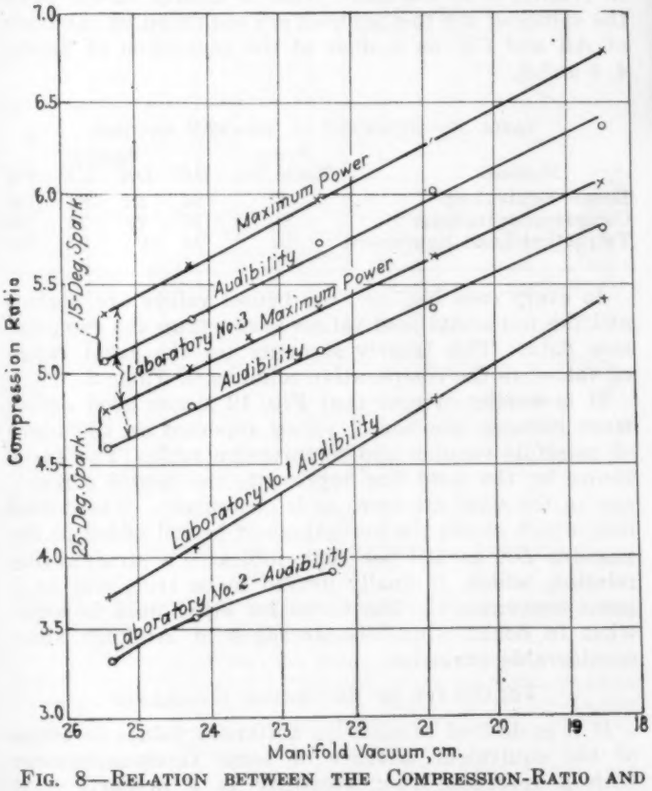


FIG. 8—RELATION BETWEEN THE COMPRESSION-RATIO AND THE MANIFOLD VACUUM FOR VARIOUS BENZOL BLENDS

This Shows a Straight-Line Relation between These Two Methods

EFFECT OF THE MIXTURE-RATIO

The first work done on this engine was a determination of the effect of mixture-ratio on detonation. Fig. 10 shows the results for several completely different types

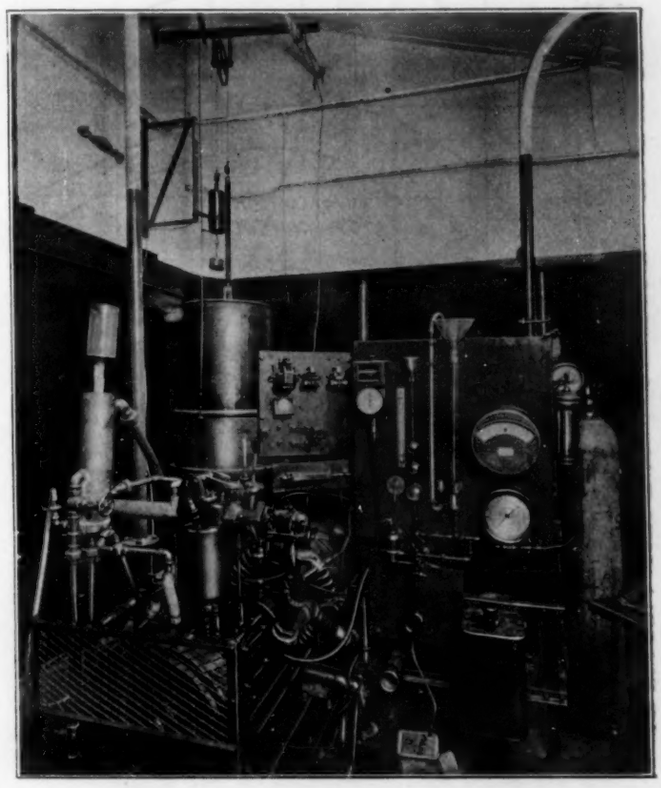


FIG. 9—SINGLE-CYLINDER-ENGINE SET-UP USED IN ANTI-KNOCK STUDIES OF THE TEXAS CO.

A Standard Steel Liberty Airplane-Engine Cylinder Was Mounted on a Marine-Engine Crankcase. The Engine Speed Was Limited to 400 R.P.M.

of fuel and indicates that any type of fuel with which we are likely to deal will give the maximum detonation at approximately a 13 to 1 air-fuel ratio. We therefore standardized on this ratio for all future work. This was a step of great importance, for the mixture-ratio of any carbureter changes appreciably with different throttle-openings. The dotted line A_1-A_2 in Fig. 10 gives the natural variation of the mixture-ratio with the throttle position for an arbitrary carbureter-setting. This is a fundamental carbureter characteristic that is responsible for one of the principal practical advantages of the variable-compression engine, since these engines operate without adjustment of the throttle. If a large number of commercial samples having similar viscosity are tested in a variable-compression engine, the mixture-ratio set for one fuel will be substantially constant for all the others at all compression-ratios. Even when fuels of different viscosity are involved, it is necessary only to make a single carbureter-setting such as that to maintain a uniform fuel-flow rate. Unfortunately, no such simple procedure is pos-

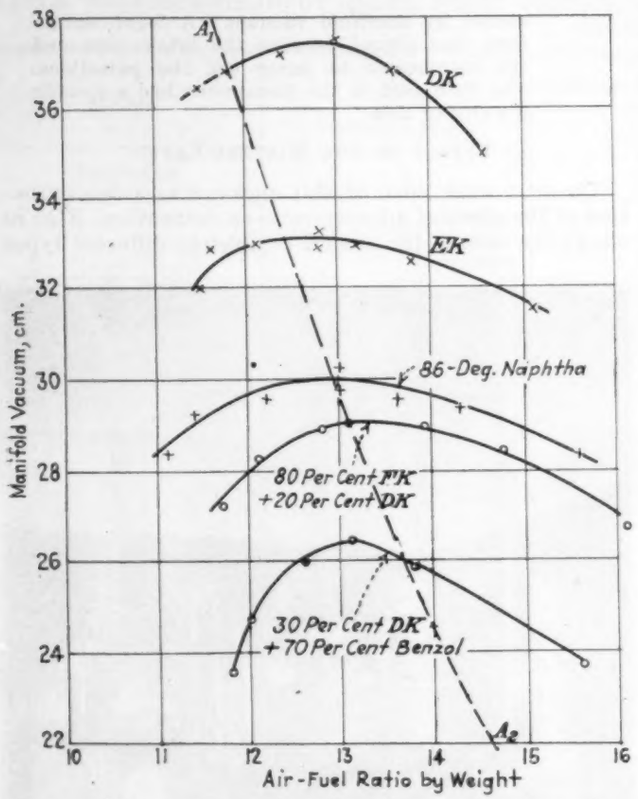


FIG. 10—EFFECT OF MIXTURE-RATIO ON DETONATION

These Curves Show That Any Type of Fuel with Which We Are Likely To Deal Will Give the Maximum Detonation at Approximately a 13 to 1 Air-Fuel Ratio by Weight

sible for the fixed-compression engine, which requires a large variation of the throttle position. The effect of fuel viscosity can be seen from the figures in Table 9 for the flow rates of three different fuels with the same carbureter and throttle settings.

TABLE 9—AIR-FLOW RATES WITH SAME CARBURETER AND THROTTLE SETTINGS

Fuel	*AK*	*EK*	86-Deg. Naphtha
Time, sec.	249	181	159

Because of the peculiarities of carbureters and the variations of the fuel viscosities, we believe that it will not be possible to coordinate satisfactorily the data between various fixed-compression engines unless the same mixture-ratio is maintained for all readings. Continual calculation of the mixture-ratio for all readings and readjustment of the carbureter consume much time, but the results obtained warrant the extra time consumed.

CONSISTENCY OF READINGS

From the time the engine was put into service, frequent readings of the detonation-point were taken for samples *DK* and *FK*. These readings are shown in Fig. 11. On the same sheet is also shown the ratio of readings of *DK* to those of *FK*, which reveals the fact that whatever causes a variation of the vacuum readings from day to day does not produce an appreciable effect on the ratio of the readings. In other words, this ratio is apparently constant for this engine, irrespective of the barometer or of carbon accumulation.

If two reference-fuels, such as *DK* and *FK*, could be standardized, any engine could be calibrated by determining the value of the ratio between the fuels. It seems, from Table 8, as if this ratio might be constant for all engines; but much more work must be done before such a conclusion would be safe. Many other mechanical factors are known to affect detonation, and we hope to carry on this type of investigation much farther.

A STUDY OF ANTIKNOCK SCALES

In Fig. 12 is shown the effect on the manifold vacuum of adding several knock-suppressing materials. The use of such mixtures as scales to measure the equivalent detonation causes many of the difficulties that arise in correlating results, because of their distorted relation to the factors directly affecting detonation. In other words, doubling the benzol equivalent of a gasoline more than doubles the allowable increase of compression. In greater detail, consider, as an example, gasoline *DK* as a "low" reference-fuel, giving it a scale value of 0, and *FK* as a "high" reference-fuel, to which might be given a scale reading of 100. Imagine a third fuel that will detonate at a compression-ratio just half-way between these two reference-fuels. It probably would fall half-way between them on any engine. On our test engine, it would detonate at a point showing 17 per cent increase of ratio. On the benzol scale, this point would correspond to 42 per cent of benzol in *DK*, which is 71 per cent of the benzol value of *FK*, that is, 59 per cent. Similarly, tetraethyl lead would have 36 per cent of the *FK* value. Thus, judging from the benzol scale, one might think that the assumed fuel would be three-quarters as good as *DK* in the allowable increase of compression, and, from the tetraethyl lead scale, one-third as good, whereas, in reality, it is one-half. This is clearly shown when the values of the fuel samples are compared on the basis of *AK* and *CK*, as is done at the conclusion of Tables 4, 5 and 8.

TABLE 10—SUMMARY OF RELATIVE RATINGS

Method	From Table No.	Sample *BK*	*DK*	*EK*	*FK*
Benzol Equivalent	4	86	32	86	145
Compression Increase	8	77	28	75	190
Tetraethyl Lead Equivalent	5	74	24	75	347

In every case but one, the benzol values are higher, and the tetraethyl lead values lower, than the compression data. This largely accounts for the great range of values in the comparative columns of Table 3.

It is worthy of note that Fig. 12 shows good agreement between the benzol values reported on the bases of manifold vacuum and compression ratio. The curve shown by the solid line represents the benzol percentage in the total mixture, as is customary. The dotted line, which shows the percentage of benzol added to the gasoline *DK* as 100 per cent, indicates a straight-line relation, which, if finally proved to be true, will be a great convenience. The curve for ethyl fluid is somewhat in doubt, since the averages of readings show considerable variation.

VOLATILITY OF REFERENCE GASOLINES

If it is desired to measure antiknock values in terms of the equivalent mixture of some knock-suppressor with a reference fuel, volatility is a property that should be borne in mind. Although this is probably not important in single-cylinder engine tests, it is im-

portant if such mixtures are to be used to test the antiknock value required by any multi-cylinder engine that is being investigated. The volatility of such mixtures should be the same as that of commercial fuel. Benzol blends fail in this respect, as shown in Table 11.

TABLE 11—RELATION OF THE PERCENTAGE OF BENZOL IN BLEND TO THE MEAN BOILING-POINT

Benzol in Blend, per cent	0	20	40	60	100
Mean Boiling-Point, deg. fahr.	282	263	248	232	176

The addition of benzol greatly distorts the whole distillation-curve. For our own use, we have found that mixtures of *DK* and *FK* are very satisfactory in this respect, but they are by no means ideal because of the difficulty of replacing these gasolines with others having the same antiknock values, when our stocks are gone.

CONCLUSIONS

(1) There is great need for further development of antiknock measurements

(2) Certain elements of technique, such as the mixture-ratio and the spark-setting, should be standardized at once

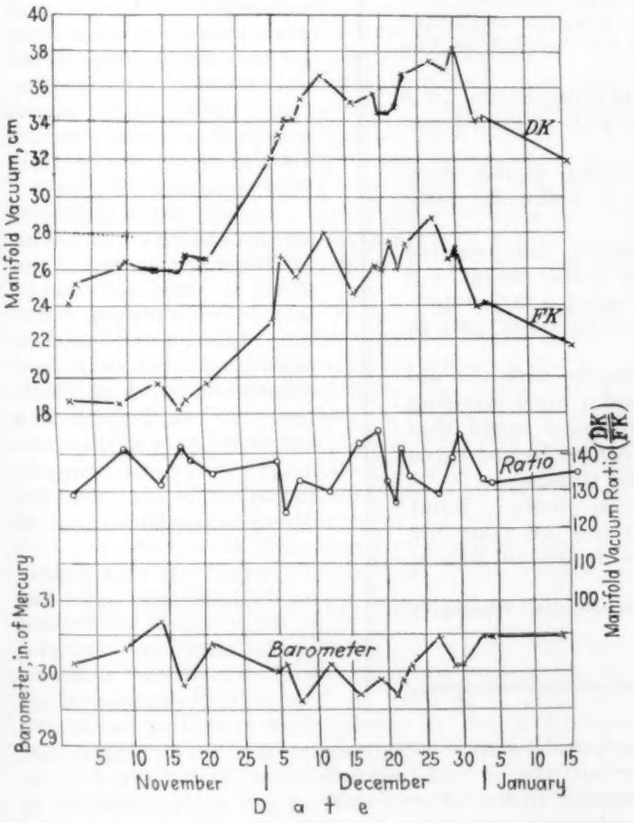


FIG. 11—READINGS OF THE DETONATION-POINT OF SAMPLES *DK* AND *FK*

The Fact Is Revealed That the Ratio of *DK to FK* Is Apparently Constant for This Engine, Irrespective of the Variations of Daily Readings, Whether Caused by the Barometer or by Carbon Accumulation

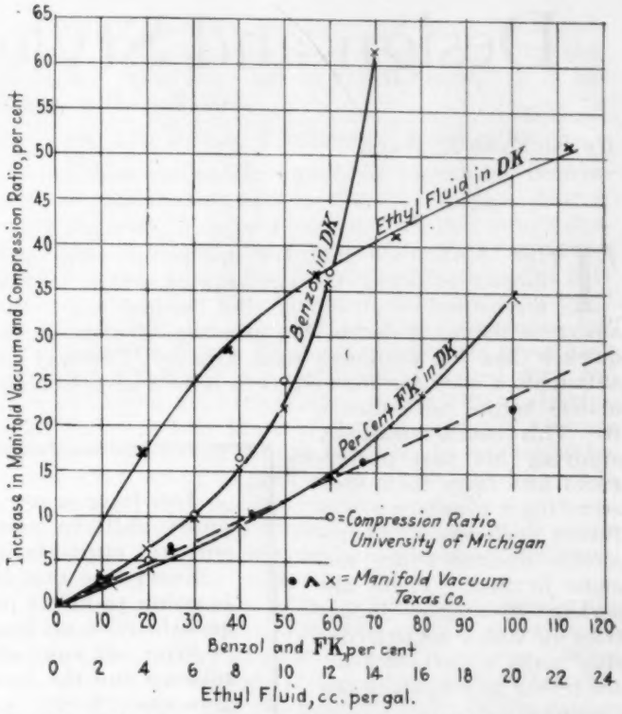

Increase in Manifold Vacuum and Compression Ratio, per cent
Ethyl Fluid in DK
Benzol in DK
Per Cent FK in DK
o = Compression Ratio University of Michigan
• ∧ x = Manifold Vacuum Texas Co.
Benzol and FK, per cent
Ethyl Fluid, cc. per gal.

FIG. 12—EFFECT ON THE PERCENTAGE OF INCREASE IN THE MANIFOLD VACUUM OF ADDING SEVERAL KNOCK-SUPPRESSING MATERIALS

Doubling the Benzol Equivalent of a Gasoline More than Doubles the Allowable Increase of Compression Pressure

(3) Intensive study should be made of the fundamental methods in use for the direct control of detonation in test-engines, such as the compression-ratio, manifold-vacuum, and the like

(4) Measurement of antiknock values in terms of the mixtures of a reference fuel with benzol or tetraethyl lead is apt to be very misleading if the peculiarities of such scales are not thoroughly understood

(5) The data given in this survey indicate that no great difference in the results probably exists whether the detonation-point is determined by audibility, the maximum power, or the bouncing-pin

(6) The size and type of engine used apparently does not affect the results

(7) Eventually, a reference fuel of low antiknock value and one of high antiknock value should be standardized

RECOMMENDATIONS

(1) A standard scale for measuring antiknock values should have some direct connection with the compression-ratio

(2) If all laboratories measured antiknock values in terms of percentage of change in the compression-ratio, for variable-compression engines, or of manifold vacuum, for fixed-compression engines, the data obtained from any engine might be converted into those obtained from any other engine by the use of a single multiplying constant

Design and Style as Selling Factors

By Richard M. Bach[1]

Annual Meeting Address

THE automobile industry speaks of style and largely relegates the elements of design to the mechanical construction. But the intelligent consumer is going to decide the question of style much quicker than the designers want him to. The way to anticipate a customer's wants is to have a good-looking article before he demands it. This can be done by studying his past preferences and from them constructing a prophecy of his future preferences. Automobile designers are not alone in that. There are perhaps 80 or more industries in which artistic design plays a part, and all are trying to anticipate the customer.

Certain ideas have come to be accepted in the automobile industry and it behooves you to find out if they are correct. You are so deeply engrossed with them that you rarely look over the fence to see what others are doing.

Anticipation of the customer's wants has its root in design, which may be called, for the sake of discussion *though not truthfully*, the exterior appearance of the car.

I construe the matter of art for profit in the automobile industry in the same way that I would construe it for the artist who carved the sculpture on the Parthenon, or the group of men who built Notre Dame Cathedral, or any man who made a suit of fine old armor; it was his business, call it his profession if you like. But he made his living by his work and succeeded as he pleased his patrons, clients or trade.

I construe business profit as of two kinds: that which is immediate and causes the pleasing tinkle in the cash register, and that which causes the tinkle to be repeated without any further great outlay of effort. In the end these amount to the same thing; namely, the satisfied customer who comes back. You may say he comes back because the car runs and serves as a good conveyance. But many other considerations enter into design as a selling factor. In the design of automobiles I have sometimes thought there is a similarity with evolution, which is remarkable primarily for the great distance it has yet to go.

You have many materials to which to apply skill to produce something that will win appreciation.

Every line that is final and expressive is going to affect people's minds and be an influence on business.

After all your delving from the bottom up and the inside out, the customer gets one "flash" and his verdict is Yes or No.

Merely changing the complexion of a car is not giving the public credit for what it is thinking.

Distinctiveness of design is the characteristic that is going to make the automobile of the future.

Give to design certain constructive advantages, by getting better talent and paying for it, and by using a larger percentage of your operating costs just to obtain design.

An artist gets his results with the aid of quick perception and a most amazing skill in finding essentials, a mind that acts as a crucible to refine impressions and extract the precious things.

You have got to crush piracy. What pride attaches to the name on your car design if so many cars are so nearly alike?

Style Up! The public is mentally styling up all the time.

How Style Enhances Value of Materials

What is design? Think of it in another industry. The potter digs out clay, so much earth at a cost of a few cents, yet in the end he may produce something that will stand in a museum for centuries to be admired and emulated and to serve as an inspiration to many persons who never cared to be potters. In the automotive industry you have many materials that go into the making of the object which, for some reason, until very recent years, has been classed simply as a vehicle for transportation purposes.

Consider the subject creatively and you will see all of these as materials to which to apply skill and to manipulate, always with the objective to produce something that will win appreciation and be pleasing. No one can tell at a distance how well it is running; the person inside knows, to be sure, but the question is, How does it look?

You may say that is dealing in externals, but I say if the externals are treated right, they are integral with the whole construction. In all of these things there is skill of two kinds: technical or manipulative, and artistic, or expressive, or creative. I recall a crude object lesson given to me recently in the value of skill. I had a drain mended by a plumber, and, when he rendered a bill for $25 I demurred, and he felt hurt, his pride in his "profession" was involved. I received an itemized bill the next morning and it showed a charge of $2.50 for specified parts supplied and $2.50 for the time of the helper. Then, in red ink, he had written across the bottom, "To knowing how to mend a drain, $20." Shortly after that I watched the plumber wipe a hot joint. He did a splendid job with a manipulative skill before which I stood in awe. So, when I saw he was charging $20 out of $25 for skill, I was willing to pay.

[1] Associate in industrial arts, Metropolitan Museum of Art, New York City.

In the costume industry you could write to the credit of skill 500 per cent above the price of the material. The realization of that skill is nothing more than the attractiveness of the garment. Other industries will offer equally surprising figures.

As Michelangelo is so often quoted as saying, the figure is in the marble and it is the sculptor's task to bring it forth. In a different way and with other materials and talents you are doing a like thing. Of course you do it with organization and many cooperative forces must be brought into play.

Customer Decides Acceptability of Design

Leonardo de Vinci, who painted The Last Supper, also designed fortifications and did a great many other things for which we bend the knee in homage because of their inspirational qualities. He is credited with the first design for an airplane. An artist is not interested intuitively in a great many things that are technological and purely practical; he gets his results with the aid of quick perception and a most amazing skill in finding essentials, a mind that acts as a crucible to refine impressions and extract the precious things.

The design of a car is in the same class with other artistic productions. The customer knows nothing about the technicalities that are bandied back and forth so glibly in workshops and laboratories; he has no time to look into them and takes your word for them. Your plain statement regarding them should be acceptable to him. But your statement as to the design of the exterior never will be acceptable to him; he decides that for himself.

You have then, by way of comparison, the old craftsman working in his material, creatively drawing forth the expression from it, knowing his material, his tools, all his processes and the final thing, and in the end also selling it. When he progresses a little further he organizes the shop so as to take advantage of any aptitude he may find in the different employes. But the consummation of his organized effort is all that the customer has to pass on. You have the task of putting into your design the same spirit of craftsmanship that made the old things salable, desirable, worth preserving.

Art Objects Were All Commodities Once

In our museum are a myriad of objects that were commodities in their day. I do not draw such sharp distinction between paintings, old lace, or a Greek gold cup as against cups and saucers by Smith & Jones, *provided they are good*, well designed. I have seen yards of canvas bedaubed with paint that I would not prefer, as works of art, to an equal number of yards of printed cretonne to hang on the window. It is entirely a question of the design, and the "emotional kick" which they bring us.

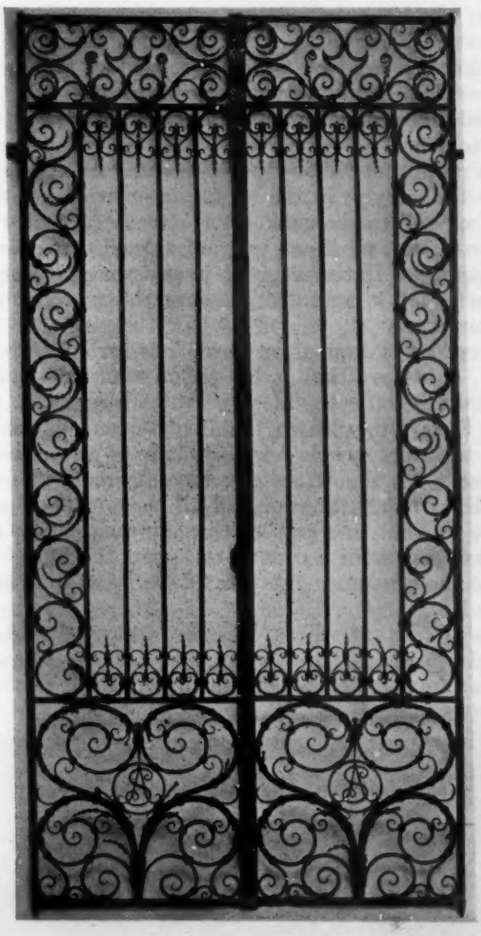
Those old things to be seen in museum galleries, and that are now used inspirationally by the industries, as is daily the case in the Metropolitan Museum, to obtain that emotional appeal which has a value in current sales and in building up new lines of current trade, were once sold across the counter and in the showrooms and somebody paid money for them and took them home as highly satisfactory purchases.

Invariably discovery and invention come first, trade follows, with the usual technical advance, and after that invariably comes art. Let us call it "style," to fit the jargon of the industry.

Skilled Public Preference Increasing

What does the public want? It may want Shakespeare in one theater and in the theater next door it wants puppets. A certain part of the public wants anything that is offered, but I assure you that one factor which is increasing is the skilled preference on the part of the public. You have to reckon with that; but build up your design, not only out of past preferences, but out of past rejections. Find out why certain types have not sold. I think if you could get an actual vote, the answers that would have anything to do with the mechanism would be only those of experts, and the answers that have to do with the eye value of the car would be, I should say, about 95 per cent of all. In any case, while the men have their heads under the hood, the women are looking at other things which represent the value of the car to them and to their neighbors and affect their general standing in the community.

Skill in preference may be technical language in the art side. Ask the man who runs a store what people are thinking about and you will get your cue. What sort of things are people refusing to buy now that they bought last year and the year before? Is the preference due to the style change, or to improvement in the quality, the caliber of the design? On the engineering side you have certain practical limitations. Beyond



these you have a slight relationship, in many cases, to the final purchaser. Your work is sifted more or less by someone else whose mind is that of a seller, not of a maker or a consumer. What does the sales person think about design as a selling point? Sellers everywhere will tell you that it is often very difficult to find sales personnel qualified beyond the consumer to judge design, with which I include style. Such words as "pretty" and "neat" are applied to a product that has all the dignity of fine design. Sales people in general do not know design. You business men cannot afford to lose sales simply because they do not sell the thing on the basis of its real caliber. It is not simply the engine set on four wheels that makes the car go. It is the appearance, the design, because you want the cars to stay sold.

I say that with the utmost assurance, for I see yours in relation to all the other industries which constitute the sum total of our needs in life today.

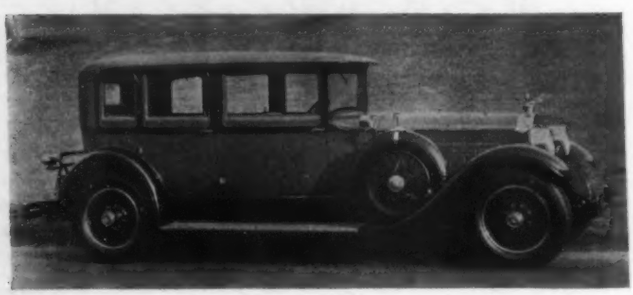
Sales Force Can Make or Break

This sales side represents a terrific power which may make or break what you are trying to do. It is all right to call the sales executives in and get their advice while you are making a decision that is only being built up. But once in the showroom, unless the car is properly presented from the design side, its sales progress is going to be hampered or possibly turned into a retrogression. Repeatedly I have seen the sales of different products impaired by an inadequate presentation of the design when the material was fine, when the utility was adequately served, when the manipulative skill all the way through the production was perfect to the *n*th degree. Then some clever man improved the design, doubled the price and went out and got orders without any trouble.

One point more about the sales side. The sales branch of the industry is in the strategic position between the producer and the consumer. It can get a good thing to the consumer and it can prevent a good thing from getting to him. It has a great power that is inherent in the fact that it actually presents the merchandise for final purchase.

Every power known on earth has an equal responsibility. You have that in the production side and in the responsibility for the design which goes into production. Every line drawn that is final and expressive is going to affect people's minds and be an influence on business. All the trials you have to make before you get a line that suits you, and all those called into conference on that line and all the opinions of the designing men, represent a concentration of thought. But in the end the consumer gets one "flash," and his verdict is Yes or No.

It is important, therefore, that there should be an adequate presentation of your hard labor on the part of the sales force. The sales personnel has not realized the responsibility that is theirs as much as yours in presenting this object of art, which is, or should be, the well-designed automobile.



Buyer Sees from the Outside In

It is in the factor of taste that the sales staff must excel the consumer. That is an inevitable thing on which you cannot put your finger and which cannot be defined; the nearest I can come to it is the hackneyed definition that taste is discrimination many times exercised.

That means setting things against one another and choosing that which pleases most; but the basis on which it pleases must be your intelligent reaction to its good appearance.

From the practical point of view, design and style fit right into the modern definition of business, which is nothing more nor less than service, of which the commodity is the embodiment. Design is the most important element in that service. If the design of the car is not pleasing, what, after all, have you to sell?

In a society of men who are so intimately associated with engineering, to speak of the outside of the car, the design, the appearance, as most important, sounds like a stretch of imagination. But with all your delving from the bottom up and working from the inside out, the customer still works from the outside in, and that has always been so.

Constant Research in Design Needed

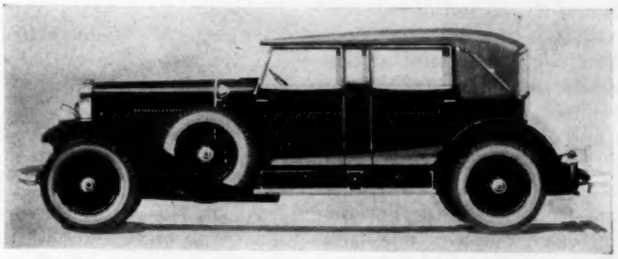
I will give you my personal angle on this subject, which I hope is partly practical and which I hope you will credit as being the result of deeply interested observation, not only of your industry but of others as well. First, research. This has to do not only with chemistry and mechanics and physics and the like; research is applicable also in the field of artistic design and style. You want a new design for the new line of models. Will you begin on it only when you are ready to design, or are you studying designs all the year round when you have no idea when or whether they are going to be produced, or whether it would be desirable to produce them at all?

The important consideration is that there must be research in design all the time. You have not achieved design in the automobile industry, you are but shaping your course toward it; and when you have reached that high type of design which is art, you will excel in your field most of the industries that man has known. We have in our Country the greatest inventive genius and the greatest fertility and vigor of mind, and out of these will come an expression in design which I am sure will find its haven also in your industry.

You have toward this one great advantage; namely, that you have very little precedent and tradition to hamper you in your work. To be sure, there have always been chariots, and sedan chairs, and horse-drawn vehicles of one kind or another. But the only precedent you can get from them is that of craftsmanship, the spirit that went into their design to make them look so good that people could not refuse to buy them. That was not done merely with coats of paint; it was the result of having the design grow out of the material and of the practical need that the vehicle was to serve.

Compare the first typewriter with those that are being sold now, and do the same for the sewing-machine and a number of other machines that are used in your own plants. In the woodworking industry you can buy

the same machine in red or green. This is going on everywhere. There is color in the bathroom, color in the kitchen and color in such a wide range in your own field. Certain colors are used because the public wants them. The great mass of the inarticulate public becomes articulate when it parts with its cash.



Now, it is one of the characteristics of our Country, and has never applied to any other republic or democracy, that every individual has a right to contribute in some way during the creation of design and to express himself as to whether it is good. Out of the aggregate preference and rejection opinions are built up which are relayed back to you and influence or control your next design.

Distinction Is the Objective in Design

Perhaps you think you are ahead of the public in this respect. You are ahead of it only insofar as you present a thing which competitors do not or cannot make. In thought the public is ahead of you. The design thought is shaping itself everywhere, not as a concrete entity to be bought, but as a criterion of appeal or expression when it comes to the final Yes or No.

Fashion changes. Changing the complexion of the car as frequently as it is changed now, is not giving the public credit for what it is thinking. You are only offering a vast selection of merchandise and in that way you are in a class with a man who sells buttons. Automobiles are not in that class. Distinction is the basis on which you work. I can cut out a series of automobile advertisements and if you did not recognize the style of make-up you would think the cars were all alike. I have heard the same things said about body designs. They are, or should be, works of art, and that is where I class automobiles. They must be characterized by distinction; unless they have that, there is very little else they can have besides an engine.

The public takes the engine for granted and knows little about it. If the engine does not go, it may be repaired. The design, however, cannot be set to rights by a repair-man; the garage is of no use so far as the design is concerned; nor is the service station.

Your whole equipment is based on the mechanical side. Think now of the side the consumer lives with and you will see there is some justice in his point of view. Listen to the comments made at the automobile shows. See who the people are who reserve opinions as to the design, and note the people whose eyes follow certain lines to see how they match and meet. Never mind those who say "That is a beautiful car." That simply means that they would like to own that nice new shiny thing.

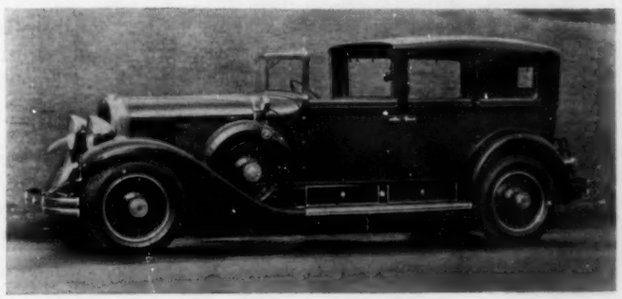
Some firm announced recently that every car it made was going to be an individual piece of workmanship and be exactly to the liking of each customer. To do a thing like that would be out of keeping with our age. You cannot make cars individually these days, because people think collectively. The distinctiveness of the design, not of an individual car, but of a make, is the characteristic that is going to make the automobile of the future, so that, when a car is mentioned by name, a certain excellent design will be associated with the name. Cars will always succeed in part, because of the mechanical efficiency; but mainly it will be their beauty that will give them distinctive quality.

Therefore, give to design certain constructive advantages in your way of looking at the industry; by getting better talent and paying for it, by using a larger percentage of your operating cost just to obtain design. Performance in the automotive field is a great deal more than power and pick-up and all the other mechanical advantages you may build into the car. It means satisfaction to the eye, when the car is standing still, as well as all those other things when it is running. This may be a curious attitude to take toward a construction that has an engine in it and four wheels under it, but that is the way I first see it; if I like it then, I watch it move, and if I still like it, I will believe anything that is told me about the engine because I believe the mechanical side has been achieved. And so does the public!

Designers Need Greater Freedom

"I don't know anything about art, but I know what I like," is an expression that indicates the beginning of taste. Find out why you like what you know you like, and you are on the fair road toward finding out how to design a car or anything else. Next, allow greater freedom to the designer. The designer in your plant must not be held down; he should not have to know about time-clocks and job-tickets. The creative part of the artistic mind does not function by the clock. The idea of the finest car you ever saw may come to a man when he is lacing his shoes in a Pullman berth. I have seen firms wake up to the fact that they have men on their pay-rolls who have not been around for 3 weeks. At the end of the fourth week they come back with a contribution the firm is glad to pay for. A casual inquiry as to where these men have been brings out the fact that for 2 weeks they have been playing around in museums of art to get ideas for designing automobiles that are not exhibited there; that for a week they may have been sauntering along Fifth Avenue watching what kind of people go into the shops, what kind of goods are shown in the windows; and part of the time they have been reading foreign newspapers and perhaps watching decorators or painters, or perhaps a man setting terra cotta. Whatever it may be, they got their ideas from all the processes of life around them, and the design, as it finally comes out, is their interpretation of all these things in terms of your material and processes and of your market.

That is the way a designer has to think. Nor do I



believe in catering to "temperament" or indulging personal whims; my suggestion is not made to condone neurosis. There is bound to be a certain amount of pot-boiling and driving, as there is everywhere, but the creative side must be given freedom and its opportunity to work at any and all times and not be limited to the production of certain things.

Again designers should be given an opportunity to produce certain purely prestige items that are not going into the catalog and which the company does not hope to sell, but conceptions that are sent out to show the world what you can do if you get to work on them and do not have to worry about extras on the price. Industries are doing that more and more. Your turn is next. In a large wall-paper factory there are myriads of machines any one of which can turn out 21 miles a day of a given pattern of paper. In a small workshop in the big one a few men are printing wall-paper from wooden blocks by hand. There are 230-odd blocks and 400-odd colors, and the men are applying the patterns and colors by hand, making a few strips a day. Why? For prestige and nothing else. Every operative in the plant feels the effect of it. He feels that same quality, that same standard seeping all the way through the plant. And on the outside the customer who sees a firm producing work like that gives that firm credit for a similar quality in every roll of bedroom paper. You are coming to that. Prestige is the best propagandist any industry can have.

Pirating of Designs Should Be Crushed

And now, a very sore subject, one I hesitate to mention and the affliction of all of our industries. You must crush piracy. You have absolutely no alternative. As has been stated, distinctiveness of design will be the expression with which you will be most proud to associate the name of the car. But what pride attaches to the name accompanying the design if so many designs are alike? The distinction is largely removed if, because one make sells well in one pattern, a great many other makers try to emulate that pattern. This copying proves my point one way, because it shows that consumers like that design, and the other firms fall in line. But what is distinctive about copying?

You cannot put your hand into another man's pocket and take his money, but you can, metaphorically, reach into your neighbor's mind and steal his design. I hope some day we shall have a law passed by Congress to protect our designs and our designers by copyright, so that the conceptions of the mind will be the exclusive property of the man who is responsible for their creation.

Style-Up, but Do Not Deceive

As for the use of resources, libraries and the museums that have pictures, sculpture, furniture, metal-work and the like, what have these objects to do with automobile design? They were all commodities in trade. It is from that point of view only that I mention them. There is something practical in the selling value of design. I can show you millinery materials worth $3 and a hat worth $30 made from them. The difference is in the design.

I am not so optimistic as to believe that this will come to pass overnight in the automobile industry or I should be in the class with the men who bought hair tonic and a hair-brush at the same time. But think back to 1894 in your industry. What was the design of which Apperson, Haynes and Olds were so proud? You have made strides in this industry that have not been made in any other in a similar period of time.

To sum up in two words all that has been said: Style-Up. Burn those words into your minds so you will remember them when you start to work on any design. I do not think you will misunderstand what the public wants. The public is mentally styling-up all the time and asking every industry to meet its demands in that way. You must fall in line and consistently offer style. You must build a standard to transcend this year's model, and next year's, too.

In certain industries now, including the automotive industry, we may find a weakness that has crept in as a result of misunderstanding or abusing the function of design. It is the use of design as a subterfuge. I cannot imagine, in this industry, a good-looking car with a poor engine. To build such a car is to use design as a subterfuge. Unless the practical end is served, the design cannot be honest. The fine car of the future will be a finely built car, excellent as to material, workmanship, performance *and* design. Weaken one of these and all will lose; weaken the last and they all fall. Style-up!

THE DISCUSSION

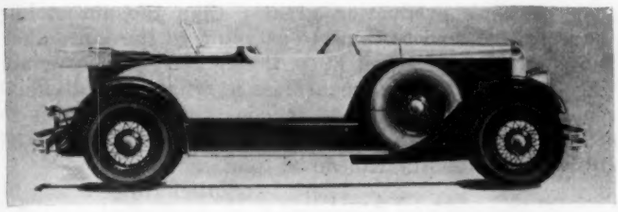
Chairman L. C. Hill[2]:—Mr. Bach's address will have a great deal to do with selling automobiles in 1928. You cannot help but be enthusiastic when you hear a man tell so many things with which you are thoroughly in accord and that you know to be the truth, but that you realize are so hard to make the executive and administrative ends of the automobile industry believe. This industry is now following itself around a circle in a process of imitation. Creative work is certainly minimized in our industry. As Mr. Bach says, it is time we tried to get something in our industry of the nature of a creative art division.

One thing that always amuses me is that every time a body session is to be given and you talk with the average technical engineer, he asks, "What are the speakers going to talk about, how to design a good body?" Most engineers seem to think that a formula, A plus X to the nth power equals a good body design, can be written. It just is not done; we all know that.

Another thing to remember is that the public is extremely fickle. It follows style, *the* thing that is *the* style this year. The public in general is not interested in the horsepower under the bonnet, or whether the car accelerates so many feet in so many seconds or decelerates a certain amount. The idea of this name's or that name's standing for the best car in the industry has disappeared. As Mr. Bach showed clearly, the public goes after the thing it likes this year, and the public is appreciative of good things. Moreover, it is the people who compose the public who pay our salaries. If we give them what they want, instead of telling them what they ought to have, we are successful in business.

One interesting development in the body business in the last year is that we are sending men into the field

[2] M.S.A.E.—Assistant sales manager, Murray Corporation of America, Detroit.



to find out what the public likes, so that we can try to give it to them, instead of deciding in the designing rooms what the public ought to have.

Seeking To Express a Fundamental Idea

President J. H. Hunt[3]:—Mr. Bach said we must have something in the automobile that expresses our own day and age. In Spencer's book, The Decline of the West, I found one idea that seemed to have automobile application. The author emphasized the fact that Greek art was primarily statuary because the Greek artist saw things on the surface, had no idea of distance, and had to have that kind of art because he was a Greek. The Gothic cathedrals built in the Middle Ages expressed the spirit of that particular people.

I am wondering if there is not some fundamental idea we wish to express with the automobile. I do not know whether we wish to create the idea of power or to typify the idea of speed, but I am sure that, when we finally accomplish what we shall have to do with the automobile, something fundamental to all of them will be the basis of the different designs. I think we are groping for it, but are we going to find it? I think so, and when we get it I believe it will express this particular age and our own particular idea of what we have in the automobile.

J. Webb Saffold[4]:—I hope that the wonderful address we have heard will cause us to do more than merely rearrange our prejudices on this subject. The lesson that I learn from it is the great value of perspective in an industry so highly specialized as ours is. It is very easy to lose perspective in this industry. Sometimes when I feel that I am getting into a rut, as everybody does, I go to southern Italy and sit on a hill and marvel at the wonderfully free balance of the old architects and how they raised their towers. When I come home I have regained my perspective and it has been well worthwhile.

Chairman Hill:—We have capable designers in this industry, but to me they represent a mold. Ideas are poured into them, you tell them what a car should be, and out of them comes a design for an automobile. Unless you send the designer away once in a while, you must keep pouring ideas into him; the same mold is there and the same design comes out of it. He must move around in the world to change his perspective so that he can create new things, or at least gain a different viewpoint.

Make the Body Fit the Man

Mr. Saffold:—When we build a factory, we lay out the machinery and build the factory around the machinery. But when we design an automobile body we design something to look beautiful on the outside and expect a full-sized adult to crawl into it. Sometimes he feels that he should have been born and brought up in the thing to fit into it. I have seen regiments of men 6 ft. 2 in. in height. They may be a small percentage of a nation of 120,000,000 inhabitants but the small percentage has some rights. It is an indictment of the industry that if I want to buy a motor-car that fits me I cannot find one.

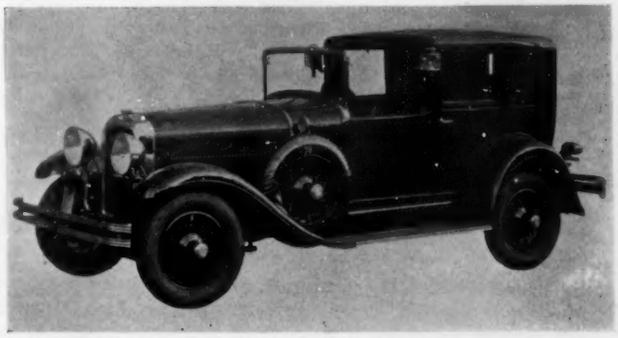
Chairman Hill:—I have found that the interior dimensions of an automobile body are controlled by the height, girth and weight of the president of the company. The sales manager and the president of a company usually control the body dimensions of the car. It is extremely difficult to secure the proper proportions in body design and at the same time have adequate space within the body to accommodate the average passenger. The body designer must take care of the man who stands 5 ft. 2 in. as well as the man who stands 6 ft. 2 in. In the case of front seats it is possible that the solution is an adjustable seat. The main reason we have not had them in the past, I believe, is that most of them have been more expensive to build than the simple stationary front seat. There is a tendency now in body design to have an adjustable front seat in the more expensive cars. I believe that the day of adjustment of the front-seat position with respect to the steering-wheel, levers and pedals and in relation to the seat cushion and back, is going to come.

I left the body engineering branch of the industry for a period of 5 or 6 years, and last year, when I returned to it, I found the engineers still discussing the same dimensions they were discussing in 1920. They were still trying to decide what were adequate head-room and leg-room and shoulder-room in an automobile body. That question, however, did not arise in the mind of the designer; he seemed to know what the size of an automobile body should be; but somebody had come to him and said, "We want one this high and so long," and he was expected to make that picture.

The industry knows that this question will need study. Several companies have taken measurements of men in their own organizations sitting in all sorts of postures in which they said they were comfortable. It is unfortunate that the Creator did not standardize the human animal, but we do try to fit the average production car to the average individual.

Must Sense and Improve on Public Taste

G. O. Goller[5]:—When Mr. Bach spoke about going to the public for suggestions for styles of cars, it brought to my mind my experience in Europe, where I grew up and learned the trade in a country that does not manufacture cars in large quantities as we do here. There the purchaser of a motor-car buys the chassis and body separately. He has the body-builder design and build the body according to his own ideas. That the ideas of



[3] M.S.A.E.—Chevrolet Motor Co., Detroit.
[4] A.S.A.E.—President and sales manager, Saffold Engineering Laboratories, Cleveland.
[5] M.S.A.E.—Engineer, Fisher Body Corporation, Detroit.

the individuals differ widely and that the taste is not always pleasing were proved when I last visited a European automobile show in 1921. Since then conditions have changed over there.

When I came to America I noticed that the body builders here were trying to please the public in general, which I thought was much better than trying to please the individual. Here the custom body-builder finds out the taste of the more discriminating part of the public and works out an advanced design, which he exposes to general criticism at the automobile salons held annually in New York City, Chicago and Los Angeles. Here the big production manufacturers examine the opinion of the general public to see which of the models and designs is liked best, and finally adopt a similar design for their next year's production. I think this is a much better system than to go to the individual and ask him for his ideas of design.

The public in America means a mass of 120,000,000 people, and 80 per cent of them will have different tastes. The individual has to be educated to be able to show good judgment of designs. You cannot always get the ideas from the public; you have to offer it designs and lines and then make your decision regarding the general trend. You must sense what the public wants and then show it something ahead of this idea.

I fully agree with Mr. Bach regarding style and think the system is good as worked out in the furniture industry or interior decorating, which have period designs. It is the same with the automobile body industry. We go through certain periods, when moldings, round corners or sharp corners, or certain color combinations generally dominate. At present we are in the period of streamline design.

In general, my idea is to be always ahead of the public rather than to let the public go ahead of you.

MR. SAFFOLD:—I should like to reply to the chairman's alibi that we cater to the average man and make our cars to suit the average man. Mr. Bach made a plea for distinctiveness. If we think catering to an average is distinctiveness, that is the kind of distictiveness that has the emphasis on the second syllable.

There was a time when the clothing industry was much standardized, especially in the lower-priced suits of clothes, but the clothing industry, which is on a scale of mass production greater than the automobile industry, has had to come to catering to the individual. While it has styles and lines, it has been able to adapt them to the individual regardless of what his individual requirements may be, and it does this clear down to $22.50 suits. If the clothing industry can do it, the automobile industry can do it too.

There is another thing that will put a kink in that alibi. In the days when we had nothing but open-body styles they were more comfortable for the driver than some cars we have today. We have made wonderful progress from the outside in. We have used beautiful fabrics to make the inside look like a lady's boudoir, but I submit that no real progress has been made in the design of the seats so far as making them fit the individual goes.

H. LEDYARD TOWLE[6]:—My experience in the automotive industry dates to 2½ years ago. At that time I was one of the very small number of artists in the industry with a real art experience. When I went among the trade calling upon car companies, the artist met, perhaps, if he was lucky, the president of the company. If he was not so lucky, he met the vice-president or the secretary or office boys and the paint superintendents and men down the line. In just 2½ years this situation has changed entirely, and the change is going to get a great deal of the art and color and life into design that Mr. Bach would like to see.

When one calls now upon the manufacturers of automobiles, or the makers of automobile bodies, he talks with other artists who are employed in an art capacity by these manufacturers. He talks with interior decorators who are employed with the idea that they shall first learn the automotive business and then apply certain of the basics of art and interior decorating to the car.

This is important in that, in a very short time, these artistic minds, communicating with one another, will come to mean something in the automotive industry; from that will come better-looking cars which will fulfill a little more the ideals we would like to realize.

[The photographs from which the illustrations used in connection with the presentation of Mr. Bach's address were reproduced were furnished by Dietrich, Inc., Fleetwood Body Corporation, John B. Judkins Co., Metropolitan Museum of Art, and Murray Corporation of America.—EDITOR.]

[6] A.S.A.E.—Director, Duco color advisory service, E. I. du Pont de Nemours & Co., New York City.

Production Engineering

INTRAPLANT HANDLING ECONOMIES

Power Trucks Effect Large Man-Power Saving—Special Uses of Lift Trucks

Following are excerpts and data on the use of industrial trucks and tractors in handling materials in process and in storage, taken from a book, Profitable Application of Electric Industrial Trucks and Tractors in Industry, recently issued by the Society for Electrical Development, New York City.

Strangely enough, industry is just now realizing that in the typical plant 80 cents is spent within the factory for transportation to every dollar spent for the use of freight cars, motor carriers, and cargo vessels. Unwieldly overhead items have long concealed this truth but the stress imposed by narrowing margins, mounting cost of so-called unskilled labor, and increasing acceptance of the mass-production principle, is now beginning to bring home the significance of this tax for transportation within the plant from the time of receipt of material to the time of shipment as product.

The power truck multiplies many times the capacity of the workman who is pushing a hand truck. It is the logical equipment to use in moving materials on wheels from inbound carrier through process to shipping, where proved minimum-cost handling practice is adopted. Because the industrial truck moves eight times the load of a hand-trucker at thrice the speed, the theoretical ratio of saving is 24 to 1.

Truckman's Capacity Increased and Space Saved

To cite specific cases, a Detroit manufacturer found that crane trucks used in the service of millwrights made an earning equivalent to the wages of 35 men. Similar equipment in the service of a railroad's repair-shop earns its cost every 30 days. A forging plant manufacturing crankshafts found that 3-ton lift-trucks multiplied the driver's capacity 18 times. In a textile mill in Massachusetts five tractors made it possible to transfer 42 men from the payroll of the trucking department. Where work accomplished is measured in terms of foot-pounds, it is not usually economical to employ man-power.

Adequate materials-handling equipment is essential to the systematic use of space. The electric truck or tractor makes possible skid-platform handling and storage practice which annihilates congestion, facilitates the profitable use of storage and manufacturing area, and eliminates confusion. At the same time rehandling of material is minimized. Where skids are used in connection with high-lift trucks it is feasible to utilize all the floor space with the full load that a given floor area will support.

Fig. 1—A Typical Lift-Truck and Load

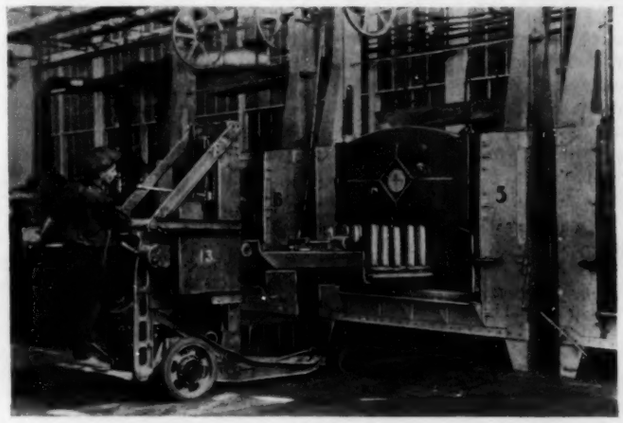


Fig. 2—High-Lift Truck Charging a Furnace

Forms and Applications of Lift-Trucks

The cost and time required for loading and unloading by hand led to building the elevating-platform truck, of the type shown in Fig. 1, which picks up and carries a load previously placed on a skid platform. This makes possible a great reduction in the rehandling of material and reduces delays in truck operation. Elevating-trucks commonly have a capacity of from 2 to 3 tons, but some are built with a capacity of 10 tons. In some plants nearly all material is handled on skid platforms in the stock-room and during manufacture.

Modifications of standard low-lift trucks are in use, such as chisel lift attachments, for handling boxed or bundled material not mounted on skids, and ladle or pot attachments for handling molten glass or metal.

Trucks of the high-lift type are used in the stock-room for tiering platforms that normally are transported by the low-lift truck. They are available also for many special uses. One example is charging heat-treating furnaces with the use of a special platform, as shown in Fig. 2, or with special fork-type box-handling trucks. One of the economies secured by charging in this way is a great reduction in the heat losses from the furnace because the time required for changing charges is made very short.

Another use of interest to the automotive manufacturer is the placing of heavy dies, which can be accomplished to advantage with the high-lift truck. This results in economy by reducing the time lost by an expensive machine while the change is being made, and by reducing the number of workers required.

PRODUCTION COMMITTEE ORGANIZED

Advisory Board and Production Committee To Develop Interests of Engineers

To meet the suggestions regarding the development of production engineering activities in the Society that were made at the Production Engineers' Conference during the Society's last Annual Meeting as reported in the March issue

of THE JOURNAL, the Committee organization for carrying on this work is along lines departing somewhat from that of the usual Committees.

It is realized that the work to be undertaken is very comprehensive and subject to conditions that do not exist in other branches of the Society's activities; and, to develop the Committee's activities most effectively, it was decided to appoint a Production Advisory Board, consisting of chief executives in the automotive industry, which would assist in establishing the broad policies and the best procedure for carrying on this work. Those who have accepted appointment on the Advisory Board are F. T. Ellis, superintendent of manufacturing, Cadillac Motor Car Co.; A. R. Glancy, president, Oakland Motor Car Co.; F. E. Moskovics, president, Stutz Motor Car Co.; and DuBois Young, president, Hupp Motor Car Corporation.

The Production Advisory Board is not a formally organized committee but will lend its cooperation by personal interview or correspondence with the chairman and members of the Production Committee.

COMMITTEE TO FUNCTION IN SEVEN GROUPS

The Production Committee, which will be the active organization, is divided into seven general groups, with E. P. Blanchard, of the Bullard Machine Tool Co., as chairman of the entire Committee. Each group of the Committee will handle a definite class of subjects which in its judgment should be taken up in order of their importance but without setting up so large a program as to hinder the desired progress in view of the facilities at the disposal of the Society. Group 1 will consider Material Handling subjects and is not yet fully organized. V. P. Rumely, of the Hudson Motor Car Co., will be a member of this group.

Manufacturing Processes and Equipment will be considered by Group 2, of which G. W. Blackinton, of the Continental Motors Corporation; F. H. Colvin, of the *American Machinist;* W. P. Michell, of the International Motor Co.; W. W. Nichols, of D. P. Brown & Co., and W. W. Norton, formerly with the Autocar Co., are members.

The work of Group 3 will relate to Time Study and Personnel Relations. Those who have accepted appointment on this group are Eugene Bouton, of the Chandler-Cleveland Motors Corporation; Harry Ford, of the Cadillac Motor Car Co.; and J. C. Mottashed, of the Hudson Motor Car Co.

Production Expense, or matters relating to production-cost determination and budgeting, is the scope of Group 4, of which H. P. Harrison, of the H. H. Franklin Mfg. Co., has accepted chairmanship, and W. J. O'Neil, of the Chrysler Corporation; E. N. Sawyer, of the Cleveland Tractor Co., and E. W. Weaver, of the Trundle Engineering Co., are members.

GROUP FOR STANDARDS DEVELOPMENT

Probably one of the most important phases of this work to be taken up is the development and use of standards in production engineering. This work is well under way in the Production Division of the S.A.E. Standards Committee, and Group 5, on Production Standards, of the Production Committee, consists of practically the entire Production Division of the Standards Committee in order to carry on the Production Standards activities by Committees most effectively. Those who have accepted appointment on this group are L. F. Maurer, of the Studebaker Corporation of America, chairman; David Ayr, of the Pratt & Whitney Co.; F. M. Bender, of the Lycoming Mfg. Co.; Jo Berge, of the Crowner Co.; Eugene Bouton, of the Chandler-Cleveland Motors Corporation; R. A. DeVlieg, of the Chrysler Corporation; A. R. Fors, of the Continental Motors Corporation; H. P. Harrison, of the H. H. Franklin Mfg. Co.; O. C. Kavle, of Manufacturers' Consulting Engineers; F. E. A. Klein, of the Pierce-Arrow Motor Car Co.; W. P. Michell, of the International Motor Co.; D. W. Ovaitt, of the Buick Motor Co.; E. N. Sawyer, of the Cleveland Tractor Co.; F. W. Stein, of Fairbanks, Morse & Co.; and W. C. Thiel, of the Waukesha Motor Co.

Group 6, to which will be assigned subjects relating to Inspection Methods, covers a very important part of production engineering. A. H. Frauenthal, of the Studebaker Corporation of America, is chairman of this group, on which J. H. Knapp, of the Detroit Gear & Machine Co., will serve as a member.

GROUP TO PROMOTE SECTIONS ACTIVITIES

One of the most fertile fields for cultivating production activities in the Society is the local Sections, especially those located in large production centers. Group 7, which will develop the Sections activities on production, has therefore been selected from the principal production centers, the following being of this group: Guy Hubbard, of the National Acme Co., Cleveland, who will serve as chairman; J. B. Armitage, of the Kearney & Trecker Corporation, Milwaukee; A. R. Fors, of the Continental Motors Corporation, Detroit; Erik Oberg, of *Machinery*, New York City, and John Younger, of Ohio State University, Columbus.

A number of projects have already been suggested for study by the several groups of the Committee. It is felt that probably the best way to proceed will be for each group to decide what subjects it should take up at this time and what procedure can best be followed in view of the conditions that will govern the activities of the members of each group. Many problems concerning the production work will without doubt have to be considered that have not hitherto arisen in connection with the other and more established activities of the Society, but it is felt that once the production work is established and going and the members of the Committee have a clearly defined view of what can be accomplished, the value of the work to the industry will be recognized as so great that it will become an indispensable part of the Society's organization and activities in the course of a very few years.

HACKSAW BLADE SIMPLIFICATION

Conference in Washington on April 11 To Reduce Variety of Styles and Sizes

The Society has been notified by the Department of Commerce that it is planning to hold a general conference on the simplification of hacksaw blades at the Commerce Building in the City of Washington on April 11, and the Society has been invited to send representatives. Probably the aggregate consumption of these blades by the automotive industries is far greater than that of any other industry, but the relative importance of this single item, so far as individual companies are concerned, is small.

Suggestion has been made to the Department of Commerce that the hacksaw blade manufacturers who desire the simplification program shall draft a proposal on the basis of a careful analysis of their sales statistics and that such a proposal be distributed to the consuming industries for comment. The Society has indicated that it would be glad to help in any such way that it can. Members and their companies who care to do so can communicate further with the Department of Commerce or arrange to have a representative attend the conference.

Uniform Motorcoach Specifications

Code Drafted by Special Committee Sent to National Bodies for Study and Endorsement

The development of motorcoach transportation as a public service has brought difficulties in the nature of conflicting public utility regulatory specifications relating to motorcoach construction to the end that the public would be protected in operating services and provided with comfort and personal service commensurate with the grants of operating privileges and the fares paid. This was a justifiable purpose but it is thought that the restrictions were adopted in many cases without adequate regard to established manufacturing standards or to regulations established by other States.

Efforts have been made to effect some degree of uniformity in these regulations, especially in a few States that have given considerable attention to this matter. But no plan was advanced for cooperative effort by a number of groups until about 2 years ago at a meeting of the Motor Truck Committee of the National Automobile Chamber of Commerce at which representatives of the Society were present and a small informal committee was appointed to formulate a uniform code of motorcoach specifications. This committee, comprising representatives of the Connecticut Public Utilities Commission, the National Automobile Chamber of Commerce, the Motor Vehicle Conference Committee, the Society, and the publication *Bus Transportation*, has presented what in its opinion is a code that includes all the motorcoach specifications that are essential for safe and comfortable passenger transportation. The code is intended as the basis of regulations in each of the several States and has been submitted to a number of National organizations and the Public Utility Commissions of the several States for study and endorsement. In preparing the code the recommendations of the Uniform Vehicle Code of the National Conference on Street and Highway Safety, which was organized by Secretary of Commerce Herbert Hoover, have been followed where they related to the Committee's code.

The substance of the rules governing detail constructions embodied in the proposed code is as follows:

Definitions of Terms

Parlor-Car type; motorcoach as designed to carry seated passengers only and having a longitudinal center aisle.

Sedan type; designed to carry seated passengers only, and having full-width transverse passenger-seats and more than two entrance-doors.

City type; designed for mass transportation, carrying both seated and standing passengers. Vehicles of this type, when used in interurban service with a seat for every passenger, will be approved for service if they conform to regulations applied to the parlor-car type.

Observation Parlor-Car type; designed with part of the passenger-compartment deck constructed on the chassis frame and part constructed over a compartment or other space not used for passenger-carrying purposes.

Single-Deck type; designed for carrying all passengers, either seated or standing, on the same level.

Double-Deck type; designed with two passenger-decks, one directly over the other. This does not include the type of construction used in the Observation Parlor-Car.

Normal Vision is that which will distinguish clearly with the naked eye or with artificial means the 20-20 line (ocular nomenclature) at a distance of 20 ft.

The Atmospheric Condition under which lighting tests are to be conducted shall be one substantially free of fog, rain, snow, mist, dust or smoke, and as termed "clear" in weather terminology.

Rule 1, Certificate of Approval for Operations; provides for inspection and approval of motorcoaches for registration and operation.

Rule 2, Maximum Length; must not exceed 33 ft. overall.

Rule 3, Maximum Width; must not exceed 96 in. over-all.

Rule 4, Maximum Height; must not exceed 14 ft. 6 in. over-all when unloaded.

Rule 5, Minimum Head-Room; clearance between the floor and the head lining, at the intersection of longitudinal and transverse center-lines of the passenger deck, of not less than the following minimum dimensions:

Type	In.
City	76
Parlor-Car and Parlor Observation-Car	60
Sedan	56
Double-Deck	
Upper Deck	60
Lower Deck	76

Rule 6, Maximum Overhang Beyond Rear Axle; the body must not extend beyond the center-line of the rear axle more than 7/24 of the over-all length of the vehicle.

Rule 7, Maximum Overhang of the Body Beyond Rear End of Chassis Frame; must not be more than 10 in. at the frame level.

Rule 8, Ventilation; motorcoaches shall be constructed or equipped to afford adequate ventilation.

Rule 9, Passenger Stop-Signal; shall be provided and must be within reasonably convenient reach of each passenger.

Rule 10, Service-Doors; regular passenger entrance and exit doors shall have a minimum clear width of 24 in.; if such doors are non-folding units swung from hinges on one side they shall in all cases open outward; if of double-hinged folding type they may open either inward or outward.

Rule 11, Emergency Doors; there must be at least one emergency-door which shall open outward and it must (*a*) be located in left side at the rear end of the motorcoach body, (*b*) have a minimum width of 24 in., (*c*) have an unobstructed aisle at least 8 in. wide leading to it, (*d*) be conspicuously marked "Emergency Door," with directions for opening, (*e*) extend from the floor to the upper belt-panel, and (*f*) be provided with a fastening device that can be released quickly in case of emergency but which shall be protected against accidental release.

Rule 12, Hinge Guards; the hinges and jambs of all non-folding swinging doors opening outward must be covered in a way to prevent passengers' fingers or clothing being caught between door jambs and pillars.

Rule 13, Destination Signs; at least one destination sign must be provided which can be read day or night, under atmospheric conditions as defined, by a person of normal vision at a distance of at least 100 ft.

Rule 14, Tail-Lamps; a ruby tail-lamp shall be located in an unobstructed position in the lower left-hand corner of the rear end of the motorcoach body or firmly attached in the same position to a body accessory. It shall be of sufficient size and candlepower to be clearly visible, under atmospheric conditions as defined, for normal vision at a distance of at least 500 ft. to the rear of the vehicle.

Rule 15, Registration-Plate Illumination; a lamp, constructed either separately or integrally with the tail-lamp, is required, located in the rear end of the motorcoach body or firmly attached in the same position to a body accessory and reflecting a white light upon the registration plate so that it is legible, under atmospheric conditions as defined, for normal vision at a distance of 50 ft.

Rule 16, Spot-Lamps; must not exceed two in number and shall be so aimed and used upon approaching another vehicle that no part of the beam will be directed to the left of the center of the road or more than 100 ft. ahead of the motorcoach.

Rule 17, Signal-Lamps; at least one is required that is yellow in color and connected so as to be lighted automatically when the speed of the vehicle is reduced by application of the brakes or release of the clutch. This lamp shall be located above the tail-lamp but below the top of the middle belt-panel or belt-line. It shall be visible, under atmospheric conditions as defined, for normal vision at a distance of 500 ft. to the rear of the motorcoach.

Rule 18, Rear Marker or Clearance-Lamps; there shall be two rear marker-lamps, ruby in color and located in the upper corners of the rear plane of the motorcoach body to show as nearly as possible the extreme width of the vehicle. These lamps shall be visible, under normal atmospheric conditions as defined, for normal vision at a distance of at least 300 ft.

Rule 19, Front Identification Lamps; two are required, purple in color and located in opposite corners of the roof to indicate the extreme width of the body. These lamps, when lighted, shall be visible, under atmospheric conditions as defined, for normal vision at a distance of at least 500 ft. ahead of the vehicle.

Rule 20, Interior Illuminating Lamps; a sufficient number of these shall be installed to give an evenly distributed illumination of at least 1 rated cp. per sq. ft. of passenger-deck area. The deck area is to be determined by the maximum inside width of the deck and the maximum inside length thereof from the plane of the instrument-board to the rear of the vehicle.

Rule 21, Dash Signal-Lamps; sedan motorcoaches shall be equipped with annunciator lamps on the dash which will be lighted automatically when doors are opened. A lamp must be provided for each door on vehicles to which this rule is applicable.

Rule 22, Step-Lamps; motorcoaches, except the sedan type, shall be equipped with a step-lamp or lamps so placed that the step or steps at the service doors will be clearly illuminated when the doors are open.

Rule 23, Operator's Guard-Rail; city-type motorcoaches shall be equipped with a guard-rail constructed around the operator's seat in a way to prevent standing passengers from obstructing the operator's view over the clear range of vision through the windshield from the driver's seat. The guard-rail must be at least 2 in. above the highest point in the back of the operator's seat.

Rule 24, Space for Passengers; in city-type motorcoaches a minimum linear dimension of 16 in. will be used to determine the seating capacity of seats obviously designed for more than two passengers.

Rule 25, Aisle Space; city-type motorcoaches shall be so constructed that an arc of 14-in. radius from the center of the aisle end of any seat shall encounter no obstructing part of a seat on the opposite side of the aisle. Parlor-car types must be constructed to fulfill the requirements of this rule with a 12-in. radius.

Rule 26, Knee-Room; a clearance at the seat line of not less than 24 in. is required between the front of the back-cushion and the nearest forward obstruction.

Rule 27, Brakes; brakes shall be adequate to control the movement of, and to stop and hold, the vehicle. There shall be two separate means of applying the brakes to at least two wheels, so constructed that no part which is liable to failure shall be common to the two. All such brakes shall be maintained in good working order.

Rule 28, Gasoline Tanks; shall be installed, filled, drained and vented outside of the body.

Rule 29, Bumpers; rear bumpers designed for heavy-duty service shall be attached to the chassis frame, and extend at least 4 in. beyond the body at the frame level.

Rule 30, Exhaust-Pipes; shall extend to the rear end of the vehicle or to a point immediately in front of the left rear-wheel or to the roof in chimney fashion.

Rule 31, Muffler; a muffler by which exhaust noise can be reasonably quieted shall be provided but it shall not be equipped with a cut-out.

The proposed code has been referred to the Motorcoach Division of the Society's Standards Committee for study and recommendations to the originating Committee for digest, together with recommendations that may be received from other National bodies and looking toward the eventual endorsement of a single uniform code. It is planned to hold a meeting of the Division, probably this month, to formulate such recommendations. Pertinent comments on the specifications, when referred to the Society's office, will be submitted to the Division. It is not expected that the Society will take final action on the specifications before at least a fairly general National agreement shall have been reached.

COMMITTEE PLANS FOR 1928

Operation and Maintenance Organization Is Outlined and Plans Discussed

At the meeting of the Operation and Maintenance Committee held in Detroit, Jan. 25, Chairman R. E. Plimpton outlined the plans for the 1928 activities. A Subcommittee was suggested for each of four general subjects: Equipment, maintenance practice, operating practices, and management. The general plan, as outlined, was favored by those present. Discussion then turned to reviewing the suggestions of subjects submitted by members of the Committee by letter, and resulted in listing the following subjects as the basis for a definite plan.

EQUIPMENT

(1) Replacement parts; interchangeability; uniformity of clearances, tolerances and fits
(2) Standardization of chassis
(3) Maximum load-allowance on vehicles
(4) Effect of installing accessories, such as air-cleaners, on vehicle maintenance costs

MAINTENANCE PRACTICE

(1) Selection and training of mechanics
(2) The problem of "non-genuine" parts
(3) Fluctuation in maintenance requirements

(4) Payment of mechanics, and time-study
(5) Analyses of garage man-power requirements per vehicle operated—separately considered for motorcoaches, motor-trucks and passenger-cars
(6) Amount of replacement parts stocks for service

OPERATING PRACTICES

(1) Training and payment of drivers
(2) Traffic and traffic-control on streets
(3) Safety training of drivers

MANAGEMENT

(1) Methods for determining costs of labor, materials, servicing equipment, and the like
(2) Budgeting of operating expenses
(3) Garage practices relating to administrative systems and record keeping
(4) Study of servicing problems depending on whether maintenance is done by fleet owners or vehicle manufacturers
(5) Standardization of variable items of operating expense
(6) Economic replacement of complete vehicles
(7) Standardization of salvaging of parts
(8) Uses of operating-cost data

Further discussion of the proposed program for the Committee resulted in designating seven Subcommittees, each to make a particular study of the condensed list of subjects as given below. The chairman of each Subcommittee is given herewith; the other members of each Subcommittee are to be selected later according to their active interest in the work and their geographical location.

SUBCOMMITTEE NO. 1

J. F. Winchester, *Chairman*

Subject.—Forms for vehicle data-sheets suitable for listing information furnished by vehicle builders on subjects such as clearances, tolerances, fits, interchangeability and replacement parts, and maximum load-allowance on vehicles.

SUBCOMMITTEE NO. 2

E. C. Wood, *Chairman*

Subject.—Study of the effect on vehicle maintenance of the use of such accessories and parts as air-cleaners, oil-filters and shock-absorbers.

SUBCOMMITTEE NO. 3

T. L. Preble, *Chairman*

Subjects.—Selecting and training of mechanics and their payment; and time-study.

SUBCOMMITTEE NO. 4

F. C. Horner, *Chairman*

Subjects.—Man-power, that is, mechanics, washers, and the like, required per vehicle operated, and seasonal fluctuation in man-power requirements.

SUBCOMMITTEE NO. 5

Ethelbert Favary, *Chairman*

Subjects.—Drivers; their training, selection and payment. Operating safety measures.

SUBCOMMITTEE NO. 6

W. F. Banks, *Chairman*

Subjects.—Budgeting methods and practices, and the purposes for which operating expense and costs are compiled.

SUBCOMMITTEE NO. 7

L. V. Newton, *Chairman*

Subjects.—Administrative systems and methods, and paper work in general.

STANDARDIZATION OF LARGE FLEETS

English Viewpoint on Elements Influencing the Selection of Suitable Types

Ideal conditions in the operation of large fleets of industrial or passenger vehicles can be achieved only as the result of long experience, not because the organizers lack knowledge of the ultimate requirements of their transport services, but owing to the manner in which businesses of this kind necessarily develop, says *Modern Transport*, an English periodical. One of the most awkward problems encountered by the maintenance engineer is that of devising a satisfactory system of working where the fleet happens to be of a mixed description. No one acquires these mixed fleets from choice, but, particularly in the case of passenger-transport concerns, they have to be purchased when smaller competitors are absorbed and thereafter worked until they can be scrapped or disposed of otherwise. Even though the original owners may have maintained in excellent mechanical condition the vehicles thus acquired, the problem of the purchaser is not greatly alleviated. In fact, the position may become somewhat worse owing to the natural disinclination to scrap a serviceable machine which has practically no market value. Thus they have to be kept running by the aid of repairs and replacements, the former often disorganizing the general routine of the shops and the latter being difficult and costly to obtain.

There can be no doubt that, from whatever angle the subject of vehicle maintenance is regarded, everything points to the desirability of type standardization, continues the article in our contemporary; but the selection of the most suitable type for any particular class of work is not such a simple matter as might be supposed. For instance, an operator may be perfectly satisfied with the results he obtains from a certain type of vehicle until a rival happens to invade his territory with vehicles which are faster or more luxurious than his own. The choice then lies between allowing a competitor to take the bulk of the traffic on certain routes or purchasing new vehicles with which the competition can be met, the latter course interfering with the uniformity of the fleet and entailing a modification of the whole system of maintenance.

DIFFICULTIES OF CHOICE

Various other considerations affect the question of fleet standardization, the importance of which does not come to light until the vehicles have been in actual service for a year or two. Almost any new vehicle can be relied upon to give satisfactory service for the first year at least with very little mechanical attention. Similarly, the first annual overhaul reveals very little in the way of excessive wear, or need of costly renewals; but, at the time of the second or subsequent overhauls, the costs may assume growing proportions, and then it is that one begins to wonder whether the best selection has been made. Records of running repairs may not show an entirely satisfactory state of affairs, and so, when additions to the fleet are required, it may be considered desirable to try some other model in the hope of being able to reduce running costs to the lowest possible figure.

Notwithstanding all the difficulties encountered in securing a uniform fleet, either for the transport of passengers or goods, the general advantages accruing from the standardization of type are sufficient to justify considerable endeavors in this direction. Some operators save themselves considerable trouble by keeping steadily to one type, almost irrespective of minor considerations, with a determination to get the best possible results from the particular vehicles they have selected, which perhaps is, in some ways, a policy possessing many advantages. At least, it has the merit of permitting maintenance on a systematic and thoroughly stabilized basis, as well as encouraging manufacturers to dispense the kind of service which is naturally afforded to their more important clients.

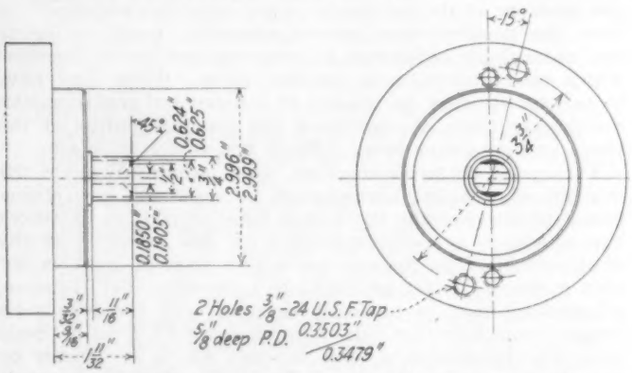
Standardization Activities

ELECTRIC EQUIPMENT MOUNTINGS

Revision of Specifications for Motor, Generator and Timer Mountings Begun

A meeting of the Subdivision on Starting Motor, Generator and Timer-Distributor Mountings was held on Feb. 15. This Subdivision was organized to consider revising the existing specifications as given on pp. 65 to 70, inclusive, and p. 60 of the September, 1927, issue of the S.A.E. HANDBOOK.

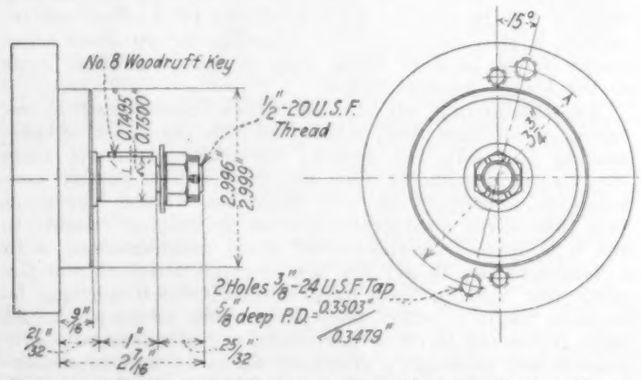
The work on timer-distributors had to do primarily with the location of the hold-down screw or clamp. The illustration shown is proposed to replace the present passenger-car types A and B for timer-distributor mountings shown on p. 60 of the September, 1927, S.A.E. HANDBOOK.



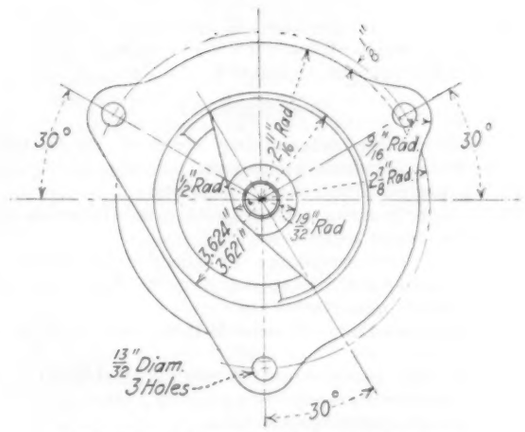
PROPOSED GENERATOR MOUNTING FOR LAMINATED COUPLING DRIVE

Consideration was also given to the development of a new standard generator-end to be used in conjunction with a ⅜-in. thick adapter-flange, it being thought that such a design would permit installations in many places where difficulty is now experienced and would give an absolutely interchangeable unit without reference to the design and shape of the flange.

This new generator-end is illustrated in two types; for laminated coupling-drives and for gear and chain drives. The pilot diameter is 3 in., as in the present specifications on p. 65 of the September, 1927, issue of the S.A.E. HANDBOOK, and the length of the pilot is ½ in. Two ⅜ or 7/16-in. screws on a 3¾-in. bolt-circle, 20 deg. above the center-line of the generator, clockwise from the driving end, are to be used for holding the adapter-flange to the generator.



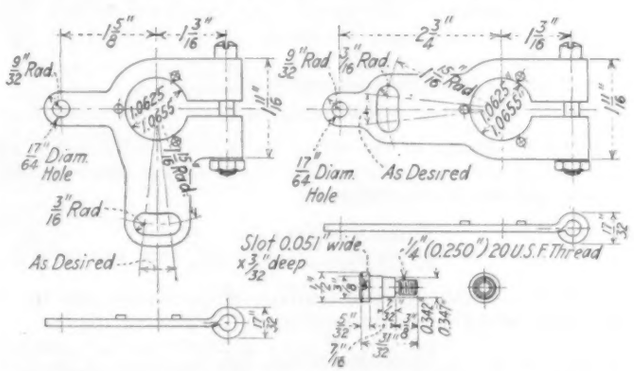
PROPOSED GENERATOR MOUNTING FOR GEAR OR CHAIN DRIVE



PROPOSED STARTING-MOTOR MOUNTING

No action was taken by the Subdivision on larger-size generators for motorcoaches, pending the action of a committee of the Automotive Equipment Association, which is working on the ratings of such generators.

Further investigation will be made of the advisability of adopting a starting-motor flange similar to the present No. 2 flange shown on p. 67 of the September, 1927, issue of the S.A.E. HANDBOOK, but with one side cut off to meet certain mounting conditions. The proposed type as illustrated herewith has found considerable usage to date, and further investigation may determine the need for the approval of this type of mounting.



PROPOSED STANDARD FOR DISTRIBUTOR HOLD-DOWN AND ADVANCE ARM

AERONAUTIC STANDARDS SESSION

Open Discussion Followed by Division Meeting To Be Held in Detroit

One of the sessions of the 2-day Aeronautic Meeting to be held by the Detroit Aeronautic Division on April 17 and 18 at the Book-Cadillac Hotel in Detroit during the All-American Aircraft Show will be devoted to the discussion of

standardization of parts for the commercial aviation industry.

There has been an increasing interest in, and demand for, standardization to afford interchangeability of parts and provide lower costs which will benefit the fast-growing army of commercial aircraft builders. The Society is meeting this demand for standardization by the appointment of Subdivisions of the Aeronautic Division of the Standards Committee, which Subdivisions are at present studying the subjects assigned to them and preparing proposed specifications on a large number of these items. Among these subjects are tires and rims, propellor mountings, engine mountings, engine-starter mountings, airplane storage-batteries, fuel and oil-pipe dimensions, fuel-system controls, hand-starter drives, instrument mountings and connections, streamline steel-tube dimensions, tail-skid shoe mountings, tank outlets and end fittings, wheel-hub dimensions, generator mounting-flange dimensions and flange-mounting for magnetos. Many other subjects have been suggested.

In view of the fact that standardization in this field has heretofore been confined largely to military and naval aircraft, there has been no opportunity for the commercial designer or operator to present his thoughts on the subject of standardization as it affects his own problems. Therefore, to provide an opportunity to discuss the entire subject, and for the purpose of obtaining information and suggestions for the guidance of the various Committees engaged in bringing this about the standardization of various equipments, the Standards Session is to be held at 2 p.m. on April 18. To this meeting have been invited executives and engineers of manufacturers of airplanes, airplane engines and equipment; and representatives of allied industries, as well as consulting engineers and men engaged in research and in the operation of air-transport lines and airports.

At this meeting, Subdivision reports on many of the subjects listed above will be submitted for general discussion. It is hoped that much of the time can be devoted also to open discussion of the problems of the whole industry as related to standardization, and that the immediate needs along these lines will be brought to the fore so that the efforts of the Standards Committee may be centralized on the items the standardization of which will have the most value.

So far as possible, copies of proposed specifications will be sent to the entire industry at a sufficiently early date, prior to the meeting, to permit of study and the preparation of comments and criticisms.

STANDARDS APPROVED BY LETTER-BALLOT

The recommendations of the several Divisions of the Standards Committee that were presented and approved at the Society's Annual Meeting in Detroit last January were submitted to letter-ballot of the voting members for final approval, and ballots were counted on Feb. 25, with the results given below:

	Approve	*Do Not Approve*	*Not Voting*
Ball and Roller Bearings Division			
Taper-Roller Bearings	364	6	230
Electrical Equipment Division			
Motorcoach Batteries	320	5	275
Storage-Battery Terminals	341	4	255
Engine Division			
Engine-Testing Forms	369	7	224
Clutch-Housing Holes	357	7	236
Hood-Ledge Lacings	353	6	241
Iron and Steel Division			
S.A.E. Steel X-1315	377	7	216
Heat-Treatment Definitions	381	6	213
Isolated Electric Lighting Plant Division			
Voltage and Capacity Ratings	275	3	322
Round Pipe-Flanges	272	3	325
Lighting Division			
Head-Lamp Laboratory Tests	335	4	261
Motorcoach Division			
Vacuum-Brake Manifold Connections	304	2	294
Parts and Fittings Division			
Passenger-Car Bumper Mountings	352	2	247
Woodruff Keys	369	4	227
Oil and Grease-Cups	364	4	232
Taper-Fitting Tolerances	364	4	232
Rivet Caps	250	3	247
Steering-Gear Connecting-Rods	344	8	248
Tinners', Coopers' and Belt Rivets	343	4	253
Screw-Threads Division			
Round, Unslotted-Head Bolts	349	6	245
Tire and Rim Division			
Rims for Low-Pressure Tires	336	5	259

A total of 3049 ballots was mailed to the members and a return of 600, about 20 per cent, was received. This is the highest percentage return ever received, the previous high return being 14.5 per cent of ballots mailed.

BALL-BEARING STANDARDIZATION

International Uniformity of Annular Type Nearly Attained—Others Being Considered

After several years of international negotiation, proposals for uniform worldwide standards for ball-bearings were discussed at the International Conference on Ball-Bearing Standardization held at Stockholm, Sweden, last October. The countries represented were Czecho-Slovakia, Germany, Great Britain, Russia, Sweden and Switzerland. The American Sectional Committee on the Standardization of Ball Bearings that is sponsored by the Society and the American Society of Mechanical Engineers, under the procedure of the American Engineering Standards Committee, was unable to have representatives present but the American points of view on the subjects to be discussed were given in a letter and tables of bearing dimensions that were forwarded to the conference.

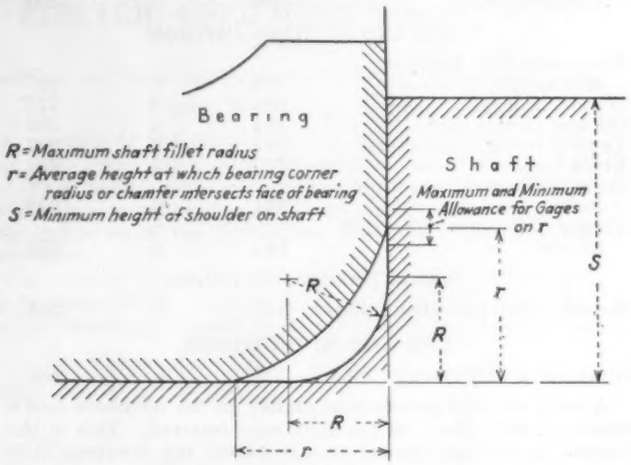
All of the countries are now in agreement on the nominal dimensions for the light, medium and heavy series of annular ball-bearings, except that in Great Britain there are slight differences in four of the bearing sizes. It is probable, however, that these differences will be eliminated in the near future. A proposal to standardize an extra-light series of annular ball-bearings was discussed but, inasmuch as the apparent need for such a series exists in only a relatively small part of industry and for aeronautical purposes, it was felt that such a standard should not be generally catalogued. The matter was referred to a small Subcommittee to prepare a report to be sent later to the natinal committees of the various countries.

Near Agreement on Metric Thrust Bearing Tables

The formulation of an international standard for metric thrust ball-bearings has been much more difficult than for the annular type. After several years of negotiation between the various countries, tables were prepared for the single-direction flat-face-type medium and heavy-series metric thrust ball-bearings. All countries now favor the proposal except Great Britain, which had already established its standard and proposed that for acceptance. The subject was referred to a Subcommittee and the British delegates were asked whether it would be possible for the

British to consider changes in their standards whereby an international standard could be agreed upon. It is understood that the British Committee subsequently stated that it would consider making changes in its specifications.

A standard that embodies such close limiting dimensions as those for ball-bearings cannot be effective unless the methods and conditions for determining the accuracy of the


Bearing
R = Maximum shaft fillet radius
r = Average height at which bearing corner radius or chamfer intersects face of bearing
S = Minimum height of shoulder on shaft
Shaft
Maximum and Minimum Allowance for Gages on r
S
r
R
R
r

PROPOSED METHOD OF MODIFYING THE CORNER RADII OR CHAMFER ON BEARINGS

dimensions are established. At the Stockholm Conference the reference temperature of 68 deg. fahr. (20 deg. cent.) was accepted by all countries except Great Britain, where 62 deg. fahr. (16.7 deg. cent.) is used. This matter was left for further consideration, but it was noted that the identity of dimensions in inches, according to the British definition, can be obtained by using an average expansion coefficient for ball-bearing steel of 0.0000115 per deg. cent., and the conversion factor 1 in. = 25.401 mm. for the British system. The metric conversion factor to be used in American bearing tables is 1 in. = 25.40005 mm.

GAGING

No definite action was taken on gaging other than to approve a resolution to the effect that in cases of dispute the dimension contested shall be decided by the practice of the National Laboratories. Where no authorities exist the errors in measurement are not to be more than plus or minus 10 per cent of the tolerances permitted, with a minimum of plus or minus 0.001 mm. for the metric system.

TOLERANCES

The international tolerances proposed for bores and outside diameters of journal ball-bearings for the international market are accepted with reservations for the following ranges of diameters:

Up to and including 120 mm., they are acceptable to all countries. Above 120 mm., and including 260 mm., they are acceptable to all countries except Great Britain; and above 260 mm. they are acceptable to all countries except Great Britain and America.

TOLERANCES ON WIDTHS

In general, it is the desire abroad, especially in Great Britain, to have closer tolerances on bearing widths than are specified in the American table. This subject was referred to a Subcommittee for further study.

ECCENTRICITY

Largely at the request of the German delegates, eccentricity and wobble were discussed at the Conference but no agreement was reached, as the British did not agree to increase the limits given in British standard specifications and the German delegates were not willing to reduce their established tolerances. It was indicated that the American, the German and the Swedish specifications permit a larger tolerance on eccentricity for the outer races than does the British specification, and as there was a desire to establish international agreement on this matter, it was referred to the Subcommittee on tolerances.

INCH-DIMENSION BEARINGS

The British delegates expressed the wish that inch-dimension ball and roller-bearings and their tolerances, as given in British specification No. 292-1927, be accepted as standard by other countries in case such standards are established. The Conference indicated that the British specification, considered from the standardization point of view, was acceptable so far as the nominal dimensions are concerned but that the tolerances for them are too small for the larger sizes; however, it recommended that, if standards for inch-dimension journal-bearings are required, those in the British specification should be used.

CORNER RADII

In discussing bearing corner-radii and shaft-fillets, it developed that the British desire to specify only the minimum corner-radii for the bearings and that in America the shaft-fillet radii are standard, whereas in the proposed international standard the mean value for the bearing corner-radii and the minimum radii for the shaft and housing fillets are given. It also developed that the corner radius specified in the international proposal for bearings of 25 and 30-mm. bore, which was 2 mm., is proportionately too large. It was proposed that this radius for these bearings be reduced to 1.5 mm., and that an inquiry be sent to the national committees in the several countries as to doing this. This was one of the criticisms that have been made by American bearing manufacturers of the proposed international standards dimensions. The Conference also approved a resolution to the effect that the minimum height of shoulder on the shaft should be discussed with the representatives of the several countries for inclusion in the standard. The accompanying illustration indicates the proposed method of specifying the corner radii or chamfer on the bearings and the minimum fillet-radii on the shafts and in the housings.

ROLLER BEARINGS

The Conference adopted resolutions to the effect that the outside diameters of roller bearings should be the same as those of corresponding sizes of ball bearings, that the width of races of roller bearings should be equal to the width of races of the ball bearings of the same nominal sizes, and that the total widths of taper-roller bearings be given further study. It was also the consensus of opinion that the corner radii of roller bearings should, so far as possible, be the same as the corner radii of corresponding ball-bearings. It was also felt that the tolerances on the bores of ball bearings should apply likewise to roller bearings, although the German delegates were not prepared to agree to this for taper-roller bearings. The Conference thought that it would be advisable to make the tolerances on the outside diameters of detachable roller-bearings conform to those on ball bearings, but there was no unanimity of opinion regarding this and the subject was left for further study. The German automobile industry indicated its advocacy of tolerances that are the same as those used in America. It was also decided to give further study to the standardization of internal dimensions of roller bearings that are of importance to bearing users.

ADAPTER-SLEEVE BEARINGS

The adapter-sleeve type of ball bearing, which was given in the international proposal for the metric diameters of shafts only, was apparently acceptable to all countries except Germany, the latter being unable to make any definite statement regarding this type of bearing. The proposed

American table for these bearings includes also the American and English systems of shaft diameters.

The conference spent some time in discussing ball-bearing line-shaft equipment but this was left for further study by correspondence between the several countries and discussion at future meetings.

Conference Reviewed by American Committee

The American Sectional Committee on the Standardization of Ball Bearings and the Ball and Roller-Bearings Division of the S.A.E. Standards Committee held a meeting in New York on March 12, at which the discussions and resolutions of the International Conference at Stockholm were reviewed by H. Tornebohm, Chairman of the Swedish Committee, who is visiting this Country. He gave the Committees much valuable information and they explained the American manufacturers' point of view concerning ball-bearing standardization, regarding which there has been much international discussion. A Subcommittee was appointed to study further the whole program of international ball and roller-bearing standardization and report back to the Sectional Committee and the S.A.E. Ball and Roller-Bearings Division. Its program includes a proposal for the minimum height of shoulder on the shaft, further study of corner and fillet radii, the relation of tolerances, ovality and conicity, eccentricity and wabble to shaft and housing fits, and the possibility of recommending closer bearing-width tolerances on individual rings.

Those present at this meeting were H. E. Brunner, of the SKF Industries; G. R. Bott, of the Norma-Hoffmann Bearings Corporation; F. G. Hughes, of the New Departure Mfg. Co.; W. P. Kennedy, of the Kennedy Engineering Co.; E. R. Carter, Jr., of the Fafnir Bearing Co.; T. C. Delaval-Crow, of the New Departure Mfg. Co.; H. R. Gibbons, of the Hyatt Roller Bearings Division, General Motors Corporation; H. N. Parsons, of the Strom Bearings Co.; Ernest Wooler, of the Timken Roller Bearing Co.; Thomas Barish, representing L. A. Cummings, of the Gurney Division, Marlin-Rockwell Corporation; H. Tornebohm, of SIS and SKF, Gothenburg; P. G. Agnew, F. J. Schlink and John Gaillard, of the American Engineering Standards Committee; C. W. Rauch, of Standard Steel & Bearings, Inc.; J. S. Tawresey, of the SKF Industries; C. B. LePage, of the American Society of Mechanical Engineers; and R. S. Burnett, manager of the Standards Department, Society of Automotive Engineers, Inc., and secretary of the American Sectional Committee.

WRONG COMPANY CONNECTION GIVEN

In the reported discussion of S.A.E. Numbers for Oil Viscosities, p. 324 of the March, 1928, issue of The Journal, O. E. Eckert's company connection was given as the Transcontinental Oil Co. Mr. Eckert is no longer connected with that company, having joined the organization of the Mid-Continental Petroleum Corporation, at Tulsa, Okla.

Properties of Lubricating Oils

STARTING with the pioneer work of Mabery and others in this Country and the researches of many foreign workers on the properties of various lubricating fractions, a vast amount of information on the chemical and physical properties of lubricating oils from different crudes has been assembled, and from these data methods have been selected for the satisfactory processing of these lubricants.

For many years empirical data have been used in classifying the physical characteristics of various oils, such as gravity, flash, fire, pour point, viscosity, carbon residue, color, emulsion, and the like, and although some of these much-talked-about properties are fairly well classified as regards the various types of lubricating oil produced, nevertheless the exact significance of certain of these tests has yet to be determined in connection with the actual operation of the motor oil in the automobile engine. The mechanical means for producing these properties have been carefully studied with considerable success, but every day newer processes are being introduced in the oil refineries to replace older and more obsolete equipment, and many bid fair to transform the oil industry even more into a chemical engineering plant than it is today. The average refiner is so familiar with the general properties of lubricating oils from different crudes or from different parts of the Country as to be able to tell from a brief physical and chemical examination of unknown products where they were made, how they were produced and some of the properties of the oils in actual service.

Lubrication Theory

Progressing from a study of empirical properties, investigations have led to a detailed study of lubrication theory, the result of which has been to restore some order to the chaos which formerly existed and to point out the importance of considering the two well-defined fields of partial and fluid-film lubrication and the well-known Zn/p relationship. The importance of viscosity at different temperatures has been emphasized, as well as the properties of oil films under a variety of operating conditions.

A study of the properties of oil films in various Government laboratories and the laboratories of several oil companies and the pioneer work of some of our research laboratories in the universities have furnished a valuable background for the information of the manufacturers of lubricants.

Much additional work on both the chemical and physical properties of oil films is necessary to characterize more definitely the so-called property of "oiliness" and to avoid placing "oiliness" into the same category as has been done frequently with "catalysis"; namely, a refuse pile for incompletely understood information.

Composition of Lubricants

Data on the exact chemical composition of lubricants are difficult to obtain and are not yet available, but sufficient knowledge has been secured to indicate the possibility that a certain type of chemical compounds, namely, unsaturated derivatives, may yet exert an important influence toward increasing the adsorption of oil films on metal surfaces. Many of these compounds are now being removed from lubricating oils and certain of them are probably of undesirable types. Further work, however, may indicate a situation analogous to the present one experienced on motor fuels, where formerly unsaturated compounds incidental to cracking processes and even cracked gasoline itself were severely condemned, whereas today some of these same products, when properly differentiated from the undesirable type of materials, are very satisfactory for producing the modern antiknock gasoline.

Such a program calls for long-time fundamental research on the chemical composition of various lubricating cuts, with the hope of classifying properly the different types of such compounds and utilizing those which are beneficial, at the same time removing, during the refining operation, those which are harmful. Several of the projects in petroleum research now being undertaken by the American Petroleum Institute bear on this particular field.—L. W. Parsons in *Industrial and Engineering Chemistry*.

News of Section Meetings

(*Continued from p.* 410)

and The Effect of Taylor's Work on Industry, by Milo Dockham.

W. R. Strickland, assistant chief engineer of the Cadillac Motor Car Co. and First Vice-President of the Society, was the guest of the student branch and was introduced by Guy R. Cowing, assistant director of the Institute. He outlined the origin and history of the Society, reviewed its standardization activities, its growth, and its present organization. Mr. Strickland then gave a brief discussion of the engineering problems involved in the design of the major units of the automobile and told of the practice of the Cadillac Company.

ALLOY STEELS AND THEIR USES

Their Suitability for Automotive Purposes Considered by Pennsylvania Section

Considering metals from the viewpoint of their resistance to corrosion, they can be classified into three groups, according to a statement made by Dr. Birger Egeberg, metallurgist for the International Silver Co., who presented a paper entitled Notes on Alloy Steel as Applied to the Automotive Industry at the meeting of the Pennsylvania Section, held on March 13, in Philadelphia. The first two classes include metals and alloys which are able to withstand oxidizing or corrosive agents; the third comprises metals that invariably will rust and be eaten away.

The members of the Section met jointly with members of the American Society for Steel Treating, the total attendance being 70 at the dinner and 150 at the technical session. At the request of Norman G. Shidle, directing editor of *Automotive Industries* and chairman of the Section, F. K. Glynn, chairman of the Society's Membership Committee, outlined the advantages of the several different grades of membership in the Society and advocated a campaign to increase the Section's membership. Adolph Gelpke, assistant engineer of the Autocar Co., acted as chairman of the technical session. Previous to the delivery of the paper, motion pictures illustrating the manufacture and assembling of the new Ford car were shown, as well as motion pictures of the chassis-assembling contest held at the 1927 Semi-Annual Meeting.

Alloy-Steel Characteristics Described

In his introductory remarks Dr. Egeberg outlined the progress of research in the development of the alloy steels and said that research is the correlation of experimental results with the facts already known from other sources. Alloys of steel containing nickel, chromium, and nickel and chromium, are the most important to the automotive industry. He said also that the automotive industry is especially interested in alloys containing up to 5.0 per cent of nickel and up to approximately 1.5 per cent of chromium, with the carbon content ranging from 0.10 to 0.50 per cent. The additions of these amounts do not materially change the nature of the metallographic constituents, but the elements exert their influence on the physical properties largely by altering the rate of the structural changes.

In straight carbon steel, especially of large sections, the speaker said, it is not possible by quenching to retard the austenite transformation sufficiently to produce as good physical properties as are desired. The addition of a small percentage of the alloying elements under consideration makes it possible to retard the transformation more effectively and hence to produce better physical properties. These types of steel will show only slightly better non-corrosive properties than straight carbon steels, and the reason for their wide use is the high physical properties which will be brought about by heat-treatment. He then discussed in detail a so-called high-carbon Krupp type of steel containing about 1.5 per cent of chromium, 4.0 per cent of nickel and 0.30 per cent of carbon.

By increasing the content of nickel, said Dr. Egeberg, the transformation range is finally lowered to a point below normal atmospheric temperature. Not even the change from austenite to martensite will take place, and the alloy steel will, therefore, be comparatively soft. About 25 per cent of nickel is required to produce the desired effect, and steels are produced which are not used exclusively because of their physical properties, but on account of their non-corrosive, non-scaling and heat-resisting qualities. Similar properties are found in silicon-chromium steels, in chromium steels of high nickel content, in chromium-tungsten steels, and in the so-called straight high-chromium steels, the last mentioned being called stainless steel. He stated also that the alloy steel to select is in many cases determined wholly by price, and in other cases with regard to what physical properties are desired together with the so-called stainless properties. Finally, consideration must be given to the corrosive agents with which the alloy steel will come into contact. He then went into detail concerning the mechanism of corrosion and gave an explanation of why it is that certain types of alloy steel are more stainless than others.

Technical details relating to transverse and bending tests, and to the corrosive and non-corrosive properties of the alloyed steels, were the main topics of the discussion which followed the presentation of the paper.

DIESEL ENGINES INTEREST BUFFALO

Large Attendance at Section Meeting to Discuss O. D. Treiber's Paper

Buffalo Section members to the number of 175 gathered on March 6 to hear and discuss O. D. Treiber's paper on High-Speed Diesel Engines, which was presented at the Annual Meeting and published in THE JOURNAL for February, p. 183. As Mr. Treiber was unable to be present, his paper was read by W. E. John, of the Buffalo Gasoline Motor Co. John C. Talcott, chief engineer of the Pierce-Arrow Motor Car Co., acted as chairman.

In the discussion, in reply to questions on double-acting engines, Mr. John said that many of the Diesel marine engines are double-acting. Most of these have water-cooled pistons, but some are oil-cooled.

There was some discussion of the Cummins method of fuel injection, described in a paper by C. L. Cummins, published in THE JOURNAL for October, 1927, and of the aluminum pistons described by H. A. Huebotter in his Annual Meeting paper, published in THE JOURNAL for March, 1928. Mention also was made of the Sperry compound Diesel engines.

Buffalo Engine on the Attendu Principle

Mr. John described engines now being built by the Buffalo Gasoline Motor Co. on the Attendu principle, described by A. C. Attendu in a paper published in THE JOURNAL for February, 1926. The design of the cylinder and exhaust ports of this engine is similar to that of other two-cycle engines, except that two exhaust valves are located in the exhaust ports to control the volume of air compressed in the cylinder during the compression stroke. The relation

of the axis of the exhaust-valve camshaft to the crankshaft can be varied by a hydraulic control on the camshaft. The exhaust valves are arranged so that when starting and at low speeds, they close when the piston reaches the bottom dead-center, thus making the entire stroke effective. As the speed builds up, the openings of the exhaust valves are varied by the hydraulic control until the engine reaches its maximum speed, when the exhaust valves are kept open until the top of the piston has covered the port. By this arrangement a varied quantity of air is compressed, so that the compression is maintained constant and the temperature of the combustion chamber, at the time of the injection, is uniform over the entire range of speed. This eliminates the trouble from slow combustion that usually is found in the conventional design.

From experiments it has been found that the flexibility of this type of engine is equal to that of a gasoline engine, Mr. John said, and a very high torque is developed at low speed. The engine has two aluminum cylinders with steel liners, weighs 475 lb., and normally develops 80 hp. The maximum speed is 2300 r.p.m. The engine is now at the laboratory of the Naval Aircraft Factory in Philadelphia.

Discussing superchargers, Mr. John told of one application in which the power of an engine had been increased 21 per cent and the fuel consumption reduced 5 per cent. Recent improvements in the Roots-type supercharger make it effective at lower speeds. The improvements consist of a new form of impeller tip and a valve that admits a predetermined quantity of oil as the engine stops, giving an oil seal to help in starting the engine.

Electric-Transmission Units Described

Atwell Tells Detroit Section About Generators and Motors for Motorcoaches—Organization of Aeronautic Division Reported

After the usual dinner and vaudeville features, the Detroit Section held its regular March meeting at the Book-Cadillac Hotel, Monday evening, March 5. Ruth Mae Fowler, who was "Miss Detroit" at Atlantic City last summer, was the headliner of the entertainers, among whom were also the Boyd Sisters, dancers on the Keith circuit; Doris Fairbanks, a musical comedy star; and Bob Sheehan with an orchestra.

Chairman Walter T. Fishleigh reported on a very enthusiastic organization meeting for the aeronautic division of the Section, held Feb. 27, which was attended by 290 men, following a dinner at which 192 were present. L. M. Woolson, of the Packard Motor Car Co., was elected chairman of the aeronautic division; W. C. Naylor, of the Stinson Aircraft Corporation, was elected chairman of the Aeronautic Meeting Committee, the other members of which are Ivan Driggs, W. B. Stout, Ralph Upson and John T. Whitaker. It is planned to have only one meeting of the aeronautic division during the remainder of this season, that to be held during the airplane show in Detroit, late in April.

Chairman Fishleigh also told of the organization of the Body Division of the Section, as reported in THE JOURNAL for March.

L. Clayton Hill, of the Meetings Committee of the Society, announced some of the plans for the Summer Meeting in Quebec and warned the members to make their reservations early. He said that arrangements are being made for a special train for members of the Detroit Section and other near-by Sections. The Detroit High-Hat Orchestra will accompany the party.

Generators and Motors for Gas-Electric Motorcoach Drive was the subject of the paper presented by C. A. Atwell, of the Westinghouse Electric & Mfg. Co. A number of photographs and curves were shown on the screen in connection with the paper, which was the same as that read by Mr. Atwell at the Pennsylvania Section Meeting in February, as recorded in THE JOURNAL for March.

Mr. Atwell described the type of transmission which has proved most satisfactory, consisting of a direct-current generator coupled to the engine and either one or two direct-current motors for driving the wheels.

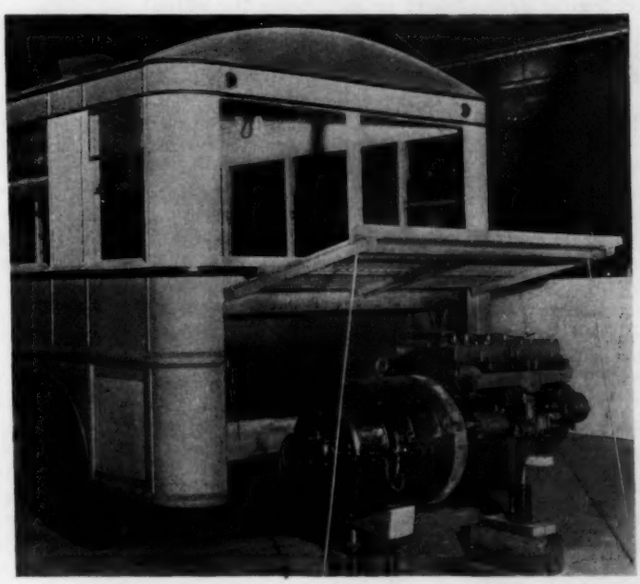
Emphasis was placed on the high schedule speeds that can be maintained by motorcoaches that must make frequent stops, when equipped with electric transmission.

The lightest possible weight is secured by using aluminum alloys wherever suitable, by allowing high operating temperature of the windings, and by providing forced ventilation for air-cooling.

In discussing the paper, F. A. Whitten, of the American Car & Foundry Motors Co., said that he had had experience with the electric transmission. He has looked a great many times at curves such as Mr. Atwell showed in his paper and has wondered whether the transmission worked because of those curves or in spite of them. Mr. Whitten confirmed the belief that the electric drive is demanded, in spite of its added weight and cost, because a higher average speed can be maintained over a route with many stops.

With a four-speed mechanical transmission, a skilled driver can get about the same acceleration as with an electical transmission, but Mr. Whitten said that it is not so agreeable for the passengers and probably is harder on the mechanism. The largest purchasers of electric-drive coaches are also among the largest purchasers of coaches with a mechanical drive, so it is evident that there are fields for both drives and the dividing line between the fields is not known exactly.

An inquiry regarding a gas-electric taxicab in Philadelphia was answered by A. K. Brumbaugh, of the White Motor Co., who explained that the Mitten interests control the trolleys and the taxicab companies in Philadelphia as well as the Philadelphia Rural Transit Co., and they are



THE ACCESSIBILITY OF THE POWERPLANT FOR REPAIR OR REPLACEMENT IS CLEARLY SHOWN IN THIS VIEW OF ONE THAT HAS BEEN REMOVED FROM A MOTORCOACH

much interested in gas-electric units. The electrical equipment of the experimental taxicab that they have built on a Willys-Knight chassis weighs about 600 lb. more than the mechanical equipment it replaces and involved an increase in wheelbase of 8 or 10 in. The cab is very easy to handle and keeps its pace well in traffic.

In reply to a question, Mr. Atwell said that most of the gas-electric coaches that have been built carry about 30 passengers and weigh 16,000 lb., empty, the electrical equipment weighing about 2000 lb. An eight-wheel motorcoach that has been developed weighs about 22,000 lb. He also explained that the controller drum, usually located at the driver's left hand, is used only for reversing, for an emergency low gear and for braking. It is not manipulated in starting the car, an accelerator pedal being the only control ordinarily needed.

Views of an Engine Builder

Engine questions were discussed by Louis P. Kalb, of the Continental Motors Corporation, who was glad that the theory of using smaller engines with electric transmission had been exploded. Larger engines would be needed, because of the electrical losses, were it not for the better acceleration obtained with the electric transmission. The power curves furnished by engine manufacturers represent the actual power of the engines, but a 24-in. fan may consume as much as 8 or 10 hp.

Mr. Brumbaugh recalled how the first horseless carriages were made by putting engines in buggies, and, with heavier springs, the vehicle was called a truck. Later, real motor-trucks were built, and the first motorbuses were made by placing cross seats in the trucks. Eventually, real motorcoaches were designed, and the gas-electric coach is a new development that is now in process.

Since the engine of the gas-electric coach must run at about 2000 r.p.m. during acceleration and its minimum speed is about 1400 or 1500 r.p.m. at about half the maximum speed of the coach, a very rugged engine is required. Additional weight also is needed in the chassis to carry the extra weight of the electrical units. In all, the gas-electric coach development by the White company weighed 3400 lb. more than a mechanical-drive chassis to do the same work. This explains the difference in cost. Mr. Brumbaugh mentioned also the loss of braking effect from the engine when it is not connected by mechanical transmission. The basis of the demand for this transmission, according to Mr. Brumbaugh, is to release the right arm of the driver. It is because the driver's right hand is left free for making change and issuing transfers that he is able to make better time, and it is because of this that it is possible to operate double-deck coaches in Philadelphia without conductors. The sensitiveness of the human body to horizontal acceleration, which has not been considered sufficiently by automotive engineers, is responsible for the preference of passengers for gas-electric motorcoaches. For these reasons Mr. Brumbaugh said that he foresees a bright future for the gas-electric coach.

Written discussion was presented also by A. I. Butler, of the General Electric Co., and Charles Froesch, of the International Motor Co.

Supercharged Motor-Vehicles

Practicability and Advantages of Supercharger Installation Presented Forcefully to the Indiana Section

Two interesting statements were made recently by David Gregg and by Louis Schwitzer. The former said that, while testing a car equipped with a supercharged engine, it was delightful to drive it at speeds from 35 to 50 m.p.h. and that it accelerated past other cars with ease. The latter asserted his belief that the supercharger is the next logical development in increasing the output per cubic inch of present internal-combustion engines and that the development of supercharger application will lead to a successful, flexible and economical two-cycle engine which will be suitable for automotive use.

The papers that included the foregoing statements were on the subject of superchargers for passenger cars and were presented at the technical session of the Indiana Section held at the Hotel Severin, Indianapolis, March 8, which was preceded by a dinner. Mr. Gregg, engineer in charge of supercharger design and development for the A. C. Spark Plug Co., of Flint, Mich., reported the results of a test made to determine the performance of a supercharged passenger-car. Due to Mr. Gregg's inability to be present, his paper was read by R. P. Lewis, secretary of the Section. Mr. Schwitzer, who is president and chief engineer of the Schwitzer-Cummins Co., of Indianapolis, chose as his subject the Practical Application of Superchargers to Automotive Vehicles.

Performance of a Supercharged Car

The experience that Mr. Gregg's company has had with supercharger application to various types of engine indicates that the best results on a passenger car call for a reasonable amount of pressure at low engine-speeds. This requirement practically eliminated the centrifugal type of supercharger and led to the development of a positive vane type of simple construction that was reasonably efficient, quiet and durable. A six-cylinder engine of 180-cu. in. capacity was selected for testing purposes which had a built-in chain drive to the magneto. By replacing the magneto with a sprocket wheel, the supercharger could then be located above the intake ports and could be driven by the chain so that the ratio of its speed to the engine speed could be changed readily.

Two methods of supercharging the engine were tested. In the first, air was blown under pressure into the carbureter. In the second, the carbureter was located at the intake of the supercharger and the supercharger outlet was connected directly to the manifold. The carbureter throttle was the only control needed. Little difference was found in the amount of power obtained with the two methods. Each gave about the same power increase, and each showed good accelerating characteristics, but because of the difficulty in securing a suitable balanced carbureter the greater part of the testing was carried out while using a standard carbureter located at the intake of the supercharger.

The supercharged engine was installed in a car and was tested side by side with a similar model of car which had a high-compression engine and used ethyl gasoline as fuel. Mr. Gregg said that the performance of the supercharged car was much superior to that of the unsupercharged car. At all speeds up to the maximum there was no laboring of the engine and there seemed always to be power in reserve. Starting and accelerating in second gear provided a get-away that left other cars far behind. The car would run smoothly in high gear at 10 m.p.h. The chain drive was noisy, but the supercharger itself was reasonably quiet and the noise it made did not have an objectionable tone.

The assertion was made by Mr. Schwitzer that it is practicable and economical to use superchargers on the average passenger-car, motorcoach and motor-truck. Saying also that probably 80 per cent of all the passenger cars are

driven 90 per cent of the time at a speed less than 35 m.p.h., he asked why the entire industry and 80 per cent of all the passenger-car operators should be penalized by excessive car weight and uneconomical operation. The average car weighs 3000 to 3500 lb. and requires about 12 to 15 hp. to drive it at a speed of 30 m.p.h., but most of the engines used in these cars will develop from 50 to 55 hp. Therefore, the greatest part of the time the engine is operated at one-third to one-fourth throttle and it is small wonder that the fuel consumption increases from 0.7 lb. per hp-hr. to become 1.3 or 1.4 lb. per hp-hr., or practically twice the amount it should be.

The speaker went on to enumerate the resulting waste due to the demand for top-notch performance which necessitates the use of engines of large piston-displacement. He said that about 350 lb. of engine weight is added as well as 6 to 10 in. of wheelbase to secure the performance which is utilized for perhaps 20 per cent of the total driving time. Considering the additional weight and length, which demand a heavier frame, body, springs, axles and tires, a total added weight of 500 to 600 lb. and an increased fuel consumption result.

Much smaller engines can be installed in motor-vehicles if used in connection with superchargers, said Mr. Schwitzer. Since the mixture is forced by the supercharger into the engine cylinders, smaller and lighter valves can be used which are less likely to overheat and warp, and smaller manifolds and carbureters are feasible. At the higher engine-speeds when excess power is required, the pressure of the supercharger takes care of the proper velocities, distribution and volumetric efficiency.

Supercharging Heavy Vehicles

For motorcoach and motor-truck service, accelerative ability due to supercharging is another main advantage, in addition to reduction in maintenance cost and better fuel economy, according to Mr. Schwitzer. To meet the recent demands of heavy-duty service, it has been necessary to increase the engine size. While engines of 400 to 420-cu. in. capacity formerly were adequate, today engines of 550-cu. in. capacity are inadequate. The speaker said also that the application of superchargers will permit the reduction of engine size to 380 or 350-cu. in. capacity. Such an engine will develop 115 hp. at 1800 r.p.m. if equipped with a supercharger. On account of the lighter reciprocating parts, the engine speed can be increased safely to 2000 r.p.m., at which speed the engine will develop 125 hp., which is in excess of the 110 hp. that an engine of 550-cu. in. capacity will deliver at 1800 r.p.m.

Mr. Schwitzer believes that the positive displacement of the Roots-blower type of supercharger makes it best for practical application, one of its advantages being that it can be built in sizes that can be accommodaed underneth the hood.

Special Engine-Design a Possibility

In the discussion following the papers, Frederick S. Duesenberg described experimental work on supercharged stock cars which he had supervised and said that, with an efficient engine and an efficient supercharger, the average car ought to develop say 25 per cent more power. In the opinion of A. L. Berger, in charge of supercharging development at Wright Field, it will be necessary to design and build engines so that they will be suitable for supercharger installation if the success of supercharging motor-vehicle engines is to be assured. He said also that the present cost of superchargers is prohibitive, and that for the present it seems most logical to increase the displacement of the engines to obtain increased power. President W. G. Wall described research work with the centrifugal type of supercharger on a passenger-car engine and said that the increase in power at 3000 r.p.m. is from 18 to 20 per cent. Other important factors of the supercharger problem were stated in considerable detail by other discussers who are authorities in their several lines.

AERONAUTIC ACTIVITIES IN DETROIT

Interesting 2-Day Program Planned for Week of All-American Aircraft Show

The Aeronautic Division of the Detroit Section, which held its organization meeting on Feb. 27, 1928, has scheduled its first regular meeting for April 17 and 18, during the week of the All-American Aircraft Show. L. M. Woolson is chairman of the newly formed Division and William C. Naylor is chairman of its Meetings Committee. Under their direction an interesting 2-day program has been arranged.

A visit to the Ford Airport at Dearborn, Mich., on the morning of Tuesday, April 17, will be the first event of the meeting, and its appeal to the aeronautic engineers who compose the Division can hardly be overestimated.

Tuesday afternoon will be left open for the members to attend the All-American Aircraft Show, which will be held at Convention Hall during the entire week from April 14 to 21. The show, conducted by the Detroit Board of Commerce in cooperation with the Aeronautical Chamber of Commerce of America, is expected to be one of the largest and most attractive exhibits ever held in connection with the aeronautic industry. The historical exhibits, demonstrating step by step the progress of American aircraft, will be an instructive feature, although greatest interest doubtless wil center around the exhibits of recent developments.

Klemin To Outline Guggenheim Competition

The program for Tuesday evening will begin with a dinner at the Book-Cadillac Hotel. The dinner, which will include entertainment, will be followed by a session at which Alexander Klemin, professor of aeronautics at New York University, will outline the requirements of the Daniel Guggenheim Safe-Aircraft Competition. Professor Klemin will discuss the design problems involved and will enter into a consideration of how some of these may be met. Since the prize for this competition is $100,000, representing the greatest incentive of this nature on the horizon at the present time for the further development of a commercial airplane, the paper should arouse intense interest.

Wednesday morning the members will have an opportunity to visit the aeronautic division of the Packard Motor Car Co., where they will see a demonstration of engines on the dynamometer and hear a short lecture on design, construction and assembly, accompanied by practical demonstration.

A luncheon of the Aeronautic Division of the Standards Committee at noon, Wednesday, will be followed by an open meeting in the afternoon at which aeronautical standardization in the commercial field will be the subject under consideration. The engineering and production representatives of the various aircraft manufacturers exhibiting at the All-American Aircraft Show will be invited to attend this open session, and it is anticipated that much valuable discussion will result.

AMERICA'S FUTURE PASSENGER-CAR

Lítle Tells Dayton Section that Epoch-Making Inventions Will Be Made

Past-President T. J. Lítle, Jr., ventured to assume the rôle of prophet and predict the trend of development of the coming American motor-car in a paper he presented under the above title at the March 13 meeting of the Dayton Section.

Some of his predictions were that, in the competition for supremacy in the next few years, many epoch-making inventions will be made; that virtually all automobile engines of the future will have superchargers built directly into

them; that the engines will be smaller but will give a greatly increased power output; and that the four-cylinder engine will pass out of the picture and be superseded by the eight-in-line engine operated at higher speed than the six-cylinder engine.

Revival of the two-cycle engine, particularly in connection with the supercharger, was predicted. There are also indications of a coming revival of interest in the air-cooled engine.

Although large cars always will be produced in a limited way, there will undoubtedly be development toward the small and medium-size light-weight car luxuriously equipped and having easy-riding qualities, according to Mr. Litle. Complete non-ferrous bodies will, he believes, be in general use in a few years, as weight and noise must be reduced. Aluminum alloys, wood, fabric and certain composite materials are more suited for body construction than steel.

Power brakes, thinks Mr. Litle, will eventually be used on all but the cheapest cars, and many radical improvements will be made in accessories. Also, chromium-plating will universally replace nickel-plating on all exposed surfaces and will be used on bearing surfaces.

The pace for striking innovation will be set by small new companies, thinks Mr. Litle, who predicted the formation of many such organizations, saying that the large corporations are sensibly conservative and usually do not wish to pioneer such innovations. Developments will come so rapidly that new models will be brought out semi-annually.

The Section meeting, which was held at the Dayton Engineers' Club, was well attended and the members asked Mr. Litle many questions on the subject dealt with in his paper. During the day preceding the evening session, Mr. Litle was the guest of the powerplant branch of the experimental division of the Air Service at Wright Field, where he was shown a number of the interesting developments that are in progress there.

Garage Design and Operation

Whitham Gives New England Section Practical Pointers on Location, Size, Layout and Operation of City Garages

The greatest needs of the garage industry are for better men and for more and better associations, such as the Society and its Sections, to throw light upon the problems by free interchange of experience. More and better equipment is needed to save time and labor, and buildings are needed that cost less. The stability of present concrete and steel building is estimated at 40 years. Is it not possible that these will become out of date and less valuable through obsolescence rather than through depreciation? Cars are becoming shorter, lower, wider and lighter and have a shorter turning radius. These trends may change the requirements of ceiling height, column spacing, elevator capacity and the like. A careful survey of modern garages shows an allotment of 250 sq. ft. for each car stall, whereas a car actually occupies only 100 sq. ft. The capitalization for each car space for city garages varies from $600 to $3000. Is this not a challenge to American inventive genius?

These were some of the statements made and questions asked by Glenn S. Whitham, of the Charles Street Garage Co., of Boston, in a comprehensive and valuable paper on the Design and Operation of Modern Garages at the March 8 meeting of the New England Section, which the speaker said was, so far as he knew, the first meeting in the history of the Society to be devoted to a discussion of garage problems.

THE LARGEST GARAGE IN THE WORLD, LOCATED AT BOSTON

AN EXAMPLE OF THE USE OF DOUBLE RAMPS

At the Extreme Left a Car Can Be Seen Descending; to the Right of This Is a Parking Space and at the Right are the Double Ramps Leading to the Floor Above. The Direction Signs on the Columns Are Supplemented by Floor Markings, One of Which Can Be Seen in the Foreground

It seems strange, said Mr. Whitham, that the garage industry has escaped technical attention so long and that so little concerted study has been given to garage problems, in view of the extent of garage investments. The total investment in garages in in-town Boston, bounded by the Charles River, Massachusetts Avenue, South Channel and Boston Harbor, is almost $20,000,000, according to the speaker, and for the entire United States the investment in modern garages amounts to approximately $2,000,000,000. Figures for 1926, furnished by D. Beecroft, of the Chilton Class Journal Co., shows that the motoring public of the United States and Canada paid for operation and maintenance an aggregate of $4,815,000,000, as compared with a retail value of approximately $3,800,000,000 paid for cars and trucks sold in the two countries.

The paper by Mr. Whitham was one of a series presented at this season's meetings of the Section devoted to service, service-station operation and garages. The Metropolitan Garage Association, consisting of about 40 leading garage men in Greater Boston, was invited to attend the meetings and take part in the discussions. Owing to the increased attendance, larger accommodations were needed, and the March meeting was held at the Hotel Kenmore, where a members' dinner preceded the technical session. Chairman Frank E. H. Johnson presided at the meeting. The April meeting of the Section is to be devoted to aircraft engines. L. M. Woolson, of the Packard Motor Car Co., is to give a paper on The Most Powerful Aircraft Engine in the World, and another well-known engineer is expected to present a paper on radial engines.

DESIGN BASED ON VERTICAL CAR MOVEMENT

The modern multi-story urban garage, which is commonly built of reinforced concrete, is based largely on arrangements for the vertical movement of individual cars at higher speed, or the vertical movement of a greater number of cars at the same speed, than prevailed in the garages of the older types, asserted Mr. Whitham in his paper at the March meeting. Basic considerations affecting the design are location; nature of load, or patronage; capacity; and method of vertical movement. The speaker favored location on a main thoroughfare for its advertising value, to catch passers-by in need of emergency service, and to enable patrons' cars to swing immediately into the stream of traffic. Location in a retail-shopping, office-building, hotel-and-club, theater or amusement, or a middle or high-class residential district was discussed in connection with the several classes of patronage and their bearing on design and equipment.

Proper size is best determined, according to Mr. Whitham, by a careful survey of the available load of business, giving full weight to such factors as trend in change of character of the district, proposed widening of or changes in adjacent streets, proposed new buildings that will furnish garage revenue, existing garage facilities, possibility of erection or enlargement of other garages, and likelihood of changes in parking regulations. Other factors to be considered are the height to which car owners will be willing to drive up ramps, traffic capacity of the street or streets feeding the garage, and number and separation of

ANOTHER GARAGE OF WHICH BOSTON IS JUSTLY PROUD

car entrances and exits. Thought should be given also to the possibility of enlarging the garage laterally or vertically.

Shape of the plot and its boundary by at least two streets, each having a width of not less than 45 ft. between curbs, are important.

Two general methods of vertical movement of cars were discussed, one by elevators and the other by ramps. One garage in Chicago, built into the back corner of an office building, has elevators designed to travel at a speed of 600 ft. per min. and serving 23 floors having a capacity of about 25 cars each. Development of ramps has been a prominent feature in the last 10 years. The Harvey and Joslin types of interior and exterior circular ramps and two-way-traffic straight ramps, and the D'Humy type of garage construction having floor levels on one side intermediate of the opposite floor levels, with connecting ramps of small gradient, were discussed.

Layout and Operation Considerations

Three important considerations when laying-out a garage design are the saving of time of customer and garage operator, comfort of customer and operator, and prevention of dissatisfaction of either. Each of these was analyzed. Mr. Whitham also dealt individually with structural materials, fire protection, heating, lighting, water supply, drainage, doors, and other details. He also discussed gasoline storage and the filling of car tanks, and the location of the repair-shop, the tire service, the accessory department and the office and waiting-room.

Under the heading of Operation, the speaker went into details of equipment for gasoline, oil, washing, merchandising, tire repairing, battery service, greasing service, and emergency service. Personnel problems and other garage operating problems were also treated.

Gasoline Gage and Ramp Models Explained

Considerable discussion followed the presentation of the paper and dealt in the main with ventilation and the use of ozone-gas machines to obviate danger from monoxide gas, the harmful effect on brake-linings of the use of soap-and-kerosene mixtures for washing automobiles, leakage of oil from pressure oil-dispersing outfits having flexible metal hose, and how to keep an accurate check on the quantities of oil dispersed.

A gage or checking-meter for storage tanks was exhibited and described by Mr. Holmes, who represented the manufacturer. This has a horizontal mercury column, a copper manifold extending down to the bottom of the tank, and a pump to force air into the tank and balance the weight of liquid in the tube. The balance established between the liquid and the air pressures operates on the mercury column so that the contents of the tank can be read in tenths of its capacity.

Mr. Joslin showed models of his ramps and explained them. With a 12-ft. story-height, a 90-ft. ramp gives a 12½-per cent grade. One model was that of the duplex ramp in the Motor Mart Garage in Boston, on which the drivers in the three or four lines of cars passing up and down do not see each other. As many as 3500 cars have gone in and out in one day without any confusion, he said.

Ramps occupy from 1000 to 2000 sq. ft. per floor. If enough elevators were installed to take care of as many cars as can use the ramps, they would occupy most of the garage and there would be no room for car storage. Fifteen per cent is the maximum safe gradient.

Inventors Glorified Above Warriors

Effects of Mechanical Invention on Human Race Portrayed Entertainingly at Cleveland Meeting—Inventors and Patents Discussed

When men emerged, after millions of years of animal life on earth, there came a new order of things—that of mechanical instead of anatomical development—which constitutes the most important evolution in the history of such life. This idea was the theme of an exceptionally interesting paper on The Importance of Mechanical Invention, presented by F. O. Richey, a Cleveland patent attorney, at the March 12 meeting of the Cleveland Section, which was held in the room of the Cleveland Engineering Society in Carnegie Hall and presided over by Ferdinand Jehle. Many guests as well as members were in attendance and took part in a lively discussion on inventors and patent matters.

Historians have not seemed to regard mechanical invention as of paramount importance in the revolutions in human life and man's progress toward civilization, and no systematic record has been made of such inventions. In recent years the effects of the development of the automobile, the telephone and radio have caused the changes to be apparent. Acceptance of the military heroes paraded in history as the benefactors of mankind and the promoters of civilization has had and continues to have an evil effect, according to Mr. Richey, who thinks that Archimedes contributed more to our happiness than did Alexander, and that the unknown inventors of window glass, spectacles, the gimlet or 100 and 1 other devices used daily have contributed more to our comfort and happiness than did Caesar, Napoleon or any other hero of history.

Invention of the bow and arrow was referred to as the most remarkable and perhaps the greatest invention of all time, because, first, it made man king of the animals and master of the earth; second, it was the first labor-saving machine; and, third, it marked the end of the supremacy of brute force and the ascendancy of mentality. The bow and arrow are remarkable also because of their development at a remote pre-historic time and, although they involved the mechanical operation of the bow, the string and the arrow to produce a common result, they must have been invented by a masterful savage mind, since nothing in nature could have suggested such a compound device and it could not have been a development.

Not only battles but whole systems of warfare were determined by the bow and arrow. The feudal system of the Middle Ages was overthrown by the long bow, which so increased the velocity of the arrow that it could penetrate the armor of men on horseback armed with the short bow. Under Genghis Khan the Tartars, whose arrow-heads were tempered in brine to harden them, conquered the world from the Yellow Sea to Vienna. This is not the only instance in which the glory of the leaders was borrowed from the inventor, said Mr. Richey, who cited numerous historic victories down to those of the World War that were due to equipment of armies with arms which were superior to those of the enemy because of some invention. More battleships are annihilated in peace-time by the inventor, he declared, than in war-time by the enemy.

Wheel and Compass Advanced Civilization

Another invention that has had tremendous consequences is the wheel and axle, as it appears in the vehicle and in the machine. It burst into history in the first form on the war chariot and in the second form as the potter's wheel. Without the wheel and axle the almost universal transportation that has brought all peoples together and spread

knowledge and understanding would be impossible, and to eliminate the wheel and axle would be to eliminate most of our modern machinery.

The third most interesting invention, in Mr. Richey's estimation, is the mariner's compass, which, though of comparatively recent origin, resulted in transportation between widely separated continents and parts of the world theretofore isolated from one another.

Invention of the steam engine by Watt, the spinning-wheel by Arkwright and his associates, and printing from movable type by Gutenberg were mentioned for their tremendous effects on civilization. Hero invented a steam engine 135 years before the birth of Christ; 565 years previously Thales of Miletus discovered how to produce static electricity and utilize it in some crude ways; the gimlet was invented several thousand years before Christ, and character stencils were used from time immemorial for printing in clay. All of these ideas lay dormant for thousands of years. For about 5000 years carpenters bored holes with the gimlet and inserted flat-ended wood-screws until someone thought of making the screws pointed.

Naval supremacy of the Carthaginians passed to the Romans because the Romans equipped their war vessels with drawbridges that could be let down upon the enemy's ships so that the superior Roman soldiers could attack the crews; and the Carthaginians were not clever enough to invent a way to prevent effective use of this device.

Economic Conditions Delayed Mechanical Progress

It is within the last 100 years that the greatest changes in human affairs have been effected collectively by inventions. Before then the people of this Country were as predisposed and prejudiced against change as were the Mohammedans of 20 years ago, said Mr. Richey. Why, he asked, was this mechanical and scientific advance so long delayed? The answer, he said, is to be found in economics. The inventor could hope for no gain unless he could keep his invention secret. Under the patent laws that have existed for about 150 years, many inventors reap a worthy reward, and the great mechanical revolution has been substantially coextensive with this situation. By far the greater gains from modern inventions are still reaped by others, however, and, in conclusion, Mr. Richey said that the greatest problem before the people of the United States, and perhaps most of Europe, is the more equal distribution of the economies and the increased comforts and pleasures created by modern inventions.

The Attorney Is Cross-Questioned

Members evidently took delight in and made the most of the opportunity to cross-question Mr. Richey in the discussion, and the attorney threatened to retaliate at his first chance at them on the stand. The first query fired at him was, What is the natural process of the mind of the inventor? And the second was, Have you a definition for an inventor? Replying that he did not think inventors, as a class, are different from anyone else, except that they are willing to work very hard and to dig deep, Mr. Richey went on to tell of the old-type "crank" inventor, who still comes around once in a while, but said that, as a result of economic conditions, there is now a high class of people who are inventing and do not care where the credit goes. The definition of an inventor is an interesting question of law. There is a twilight zone between the mechanic and the inventor and between mechanical skill and invention, and it is the province of a court of equity to decide whether a patent reflects invention or only mechanical skill.

Another question, put by Fred A. Cornell, was whether present invention is not sometimes the result of mere accident, in which a large number of false values are set up and become a brake on industry rather than an incentive to the expansion of the inventions into public usage. Mr. Richey admitted that many patents are issued on mechanical devices which should not be issued, but maintained that while the patent law is not perfect, the Patent Office probably is more efficient than other Government departments and is absolutely honest. There has been only one instance of crooked work in the Patent Office in 100 years, he said, and the man who did it was sent to the penitentiary.

Prejudice against new inventions has been overcome, the speaker said in response to a question by S. L. Bradley, chairman of the Section; the change in the whole mental attitude of man that has been effected largely by inventions is one of the greatest social revolutions.

Cannot Force Patent Into Use

Eugene Bouton wanted to know if there is any law by which the manufacturer of a useful patented article can be forced, either by infringing the patent or making a large corporation, which owns the patent or controls rights under it, to bring the article out and use it. To this Mr. Richey said that, although no such power exists under law, there seems to be a growing tendency for the courts to take a very different attitude toward "paper patents" on which there has been no commercial activity and those on which there has been such activity, and to sustain patents in the latter class.

In reply to a question by Chairman Jehle, Mr. Richey said he had always been inclined to advise his automobile clients against taking out foreign patents, although there has been a good deal of activity in this direction in recent years. The desirability of a foreign patent depends on the value of the device in foreign countries.

First Steps To Protect an Idea

The first step to take in securing protection of a conception, the speaker said in answer to a question by Max L. Jeffrey, is to keep a record of the development by (*a*) recording the time it is first conceived, (*b*) recording the date of first telling someone else about it, (*c*) having the drawing and description witnessed and dated, and (*d*) recording the first making and testing of the device. All these steps should be witnessed and the records preserved.

What percentage of inventors who take out patents ever realize as much as the patents cost them? inquired Mr. Wells. Speaking from his own experience, responded Mr. Richey, one would be surprised at the number who do realize on their patents. The average inventor who has made money in inventing does about as well as, if not better than, men in most other occupations.

Mr. Wells also wanted to know if an invention can be protected, before patenting it, until one is sure there will be a demand for it. To this Mr. Richey stated that, if a man is confident that his invention will be a success, he should not hold back; each case must be decided on its individual merits. It is merely a matter of financial investment.

BRAKING PROBLEMS OF THE WEST

Northern California Section Meeting Shows Severe Requirements of Coast Operation

How much more acute is the problem of providing adequate brakes for cars in operation on the West Coast than in other parts of the Country is indicated by the interest shown in papers on brakes at the Section meetings in California. A well-attended meeting on the subject was held by the Southern California Section in February, and the interest seemed just as great at the Northern California Section meeting on March 8.

About 60 members attended the dinner at the San Francisco meeting, at the close of which G. B. Ridley, chairman of the Section Nominating Committee, reported the names of the following men who were nominated for officers of the Section for next year: Chairman, S. B. Shaw; vice-chairman, Horace Hirschler; vice-chairman (East Bay), Herbert L. Miller; treasurer, Fred L. Sargent; secretary, William S. Crowell.

Announcement was made that the April 12 meeting will

be an East Bay meeting held at the University of California. Dinner will be served in Stephen's Union Hall, after which there will be inspection of the laboratories and a technical meeting at which will be presented papers on aerodynamics and superchargers for both automobile and airplane engines. A large number of engineering students in the University will attend the meeting.

Before the presentation of the papers on brakes, N. B. Burkness was called upon to introduce the subject, as the vehicles of the California Transit Co., with which he is connected, are driven about 30,000 miles per day. Mr. Burkness said that brakes are the biggest item of up-keep expense in his operation. All kinds of brakes and brake-linings have been and are being tried, and an immense compilation of brake data has been secured.

Road speeds of 60 m.p.h. are common, and the brake requirements of a vehicle weighing with load from 25,000 to 35,000 lb. and running at 60 m.p.h. are very exacting. Air brakes are being used, with 150 lb. per sq. in. air pressure in the tank. It is hard to find the right materials for the brake-drums and brake-shoes.

Is Brake Development Lagging?

In the first paper presented, F. R. Maulsby, superintendent of motor-vehicle equipment of the western department of the American Railway Express Co., sketched a background of the development of brakes in horse-drawn vehicles, bicycles and early motor-cars, and said that progress in brake development has not kept pace with refinement in other parts of the vehicle. Particularly on the West Coast, where distances are great, speeds high and grades frequent, brakes that have been good enough in the comparatively level Middle West are not satisfactory.

If a 2-ton truck with a normal gross weight of 10,000 lb. is brought to a stop from a speed of 40 m.p.h. within a distance of 150 ft., according to Mr. Maulsby, the kinetic energy to be absorbed is 537,000 ft-lb. This is equivalent to enough heat to raise the temperature of two quarts of water from the freezing-point to the boiling-point in 5.1 sec.

The service organization of the express company is required to exercise perpetual vigilance on brakes, with the result that the company has not had a single accident due to brake failure.

After some discussion of the suitability of brakes of different types for various capacities of truck, W. W. MacDonald, of the MacDonald Motors, Inc., said that his company has reduced the size of its trucks to allow the brakes to catch up. C. C. Smith, of the Westinghouse Air Brake Co., told of the application of the new Westinghouse vacuum units to the brakes of vehicles ranging from a light six-cylinder passenger-car to a 2½-ton truck.

John W. Watrous, district manager of Ferodo & Asbestos, Inc., then presented his paper on Causes of Brake-lining Failure, which he gave at the Feb. 10 meeting of the Southern California Section, as reported in THE JOURNAL for March.

Fundamental Considerations of Safety

The Relation of Brakes to Highway Safety was the subject of a paper read by Dr. F. C. Stanley, of the Raybestos Co., who said that an acceleration of 10 ft. per sec. per sec. is a remarkable performance. However, many cars are capable of deceleration at the rate of 25 ft. per sec. per sec., provided the condition of the pavement permits this. The friction coefficient of the tires on the pavement varies between 0.03 and 0.80. Dr. Stanley assumes 0.6 as a normal coefficient and finds that a car with two-wheel brakes, running at 20 m.p.h., cannot be stopped in less than 37 ft. Four-wheel brakes, he said, reduce the theoretical distance to 22.2 ft.

Dr. Stanley pleaded for a more general recognition of the distance actually required for stopping at high speed and for limiting the driving speed accordingly, because there may be some unexpected obstruction in the road ahead. Adequate brakes are quite as necessary on commercial vehicles as on passenger-cars.

The floating cams of the brakes on the new Ford car were described by Dr. Stanley, who said that they give more perfect equalization of pressure between the two shoes than is common.

Operating adjustment was said by Mr. MacDonald to have an important influence on brake clearance and the resulting brake-action. It is necessary to make the adjustment of tapered roller-bearings loose because of the hub expansion from the heat of brake application. As a result, brake-bands cannot be properly centered and the pressure and wear are uneven.

Hardness of brake-drums was the subject of inquiries. Dr. Stanley said that the 45-point carbon-steel drums used on a certain expensive car require eight drawings and three annealings to produce. They are hot-drawn except for the final cold-drawing operation. Chromium-plating is said to be unsatisfactory for brake-drums because of the thinness of the coating.

An Engineering Tour of Europe

Milwaukee Section Gets an Interesting Report from Fisher of His Trip with Horning

With about 100 guests at dinner and 30 more at the meeting following, the Milwaukee Section met on March 9 at the Milwaukee Athletic Club. After announcing invitations to attend meetings of other engineering societies in Milwaukee and of the talk to be given by Henry Hubbard, assistant director of the Bureau of Standards, at the next meeting of the Section, Chairman Fred M. Young introduced James B. Fisher, chief engineer of the Waukesha Motor Co., to tell of his experiences and observations during his trip to Europe last autumn.

A Helicopter in Flight

First impressions of Great Britain were gained in approaching Southampton through the Solent, where the development activities of the British Navy were apparent in the form of may torpedo chasers, submarines and seaplanes. Seaplanes to the number of 15 or 20 were in the air and, as the passengers watched, a helicopter rose almost vertically from Croydon Field and sailed around the ship. This is said to be the only successful helicopter in the world. Its propeller seemed to be about 20 ft. in diameter and rotated rather slowly. It was an ungainly looking craft and did not impress the speaker as being very practical.

Exceptionally prompt freight service and low-cost passenger service on the British railways make competition by motor-trucks and motorcoaches very difficult, although tours with chartered motorcoaches are extensively patronized. Narrow, crooked roads and sharp, dangerous curves make motor-car driving difficult in England. The Roman roads in England are an exception, following straight lines. One feature of British road service is the patrolling by representatives of the Automobile Club of England with motorcycles and side-cars, who carry spark-plugs and spare parts to help car drivers who may be in trouble on the road.

The average English car owner feels above driving his own car. Even owners of the cheapest makes of American.

cars have liveried chauffeurs. One explanation of the advanced engineering in American cars is the fact that American engineers have the advantage of 100 miles of road experience with their models to 1 mile with a British model.

London Omnibus-Overhauling Methods

The Chiswick station of the London General Omnibus Co. was found very interesting. With about 4500 ommibuses averaging about 150 miles per day, each is washed carefully every day and checked up about once in 10 days. After 20,000 miles the chassis is completely taken down on a continuous track like an assembly line. Every unit is torn down piece by piece. After overhauling, it is reassembled on a similar line, the work following a rigid time-schedule. No attempt is made to reassemble a chassis with the original units but a careful record is kept, showing such details as which of the seven or eight standards of cylinder-bore sizes is in the engine.

Among the operations of overhauling are testing the cleaned and polished axles by means of a solenoid and fine iron filings. Filings will adhere in a small ridge at any fine or incipient crack. Neither a spray nor a brush is used for painting. The vehicle is tipped slightly to one side and the paint is applied through a wide nozzle like the nozzle of a vacuum cleaner.

Police regulations on mechanical details are very strict. One detail is the requirement for a trough around the oil-pan ending in a spout at one side with a container to catch any oil that may leak from the engine!

Mr. Fisher considers that British industry has not adjusted itself to the times since it has lost its world supremacy, and he believes it will take generations to overcome the antagonism between labor and management. The general obligation of plant managers to submit all questions of management to the directors is mentioned as a handicap.

James B. Fisher

Research Work at the Ricardo Laboratories

The Ricardo laboratories in London were commented on as the largest in the world devoted entirely to engine testing. About 85 men with 12 dynamometers are working on everything from a 2-in.-bore motorcycle engine to a 20-in.-bore Diesel engine. The observers are trained by years of experience. The largest dynamometer has a capacity of 300 hp.

There is a general belief that high-compression engines overheat and do not run smoothly. Mr. Ricardo's work has resulted in compression pressures as high as 6½ to 1 on passenger-car engines, with smooth running and a reduction in the amount of heat wasted through the cooling water and exhaust. This result is obtained by controlling the rate of pressure rise. The pressure rise of one engine was 22.6 lb. per degree of crankshaft travel, while that of another engine was 60.3 lb. This is said to represent the difference between a rough and a smooth engine.

Flame propagation is studied by a device originated at Waukesha and adopted by Ricardo. It consists of a series of six quartz windows in the cylinder-head that may be viewed through a stroboscope. The progress can be recorded photographically. For checking the volumetric efficiency of an engine there is a large air-tank like a gas accumulator, with connecting pipes throughout the laboratory.

One memorable experience was a visit with Sir Dugald Clerk, who did much for the scientific development of the internal-combustion engine in its early days.

In Ghent a plant was visited where the Ingersoll-Rand Co. has Diesel engines manufactured to operate its air-compressors. The cost of these engines in America is less than that of American engines because the Belgian mechanics are paid from 12 to 18 cents per hr. During the war, this plant was occupied by Germans, employing about 800 men. With 48 hours' warning every piece of movable equipment, including the line-shafting, was moved out before the arrival of the British. Reparations amounted to about one-fifth of the amount lost and the business was refinanced only through American connections.

In Berlin there were accidental meetings with a few Americans, among them John Squires, who is managing director of the Chrysler plant there. Mr. Squires reported several shocks that he had given to his German associates by moving from an isolated office and by holding conferences with the foremen. He was able to obtain better cooperation between the departments in this way and soon they were enthusiastic in telling their friends how they were working on the American plan.

German mechanics are paid higher wages than those in Belgium, that is, 15 to 20 cents per hr. A very fine toolmaker earns 35 cents per hr. The German manufacturer thinks in terms of low wages; not low cost per piece. As a result, the European laborer is paid so little that he cannot buy the common luxuries of America, and there is no prosperity.

One of the engineers met in Germany was Dr. Shiefferstein, who has made some very interesting investigations on vibration and power transmission. It has been found that a flying goose produces a pressure wave and geese arrange themselves in flight to take advantage of this. Also, they flap their wings in definite relation with each other so that each takes advantage of the air impulses created by the wings of the bird ahead.

With this as a basis, Dr. Shiefferstein has developed principles of loose coupling and applied them to mechanical uses. One of them is a variable-torque transmission in which is a small crank-arm rotating at engine speed, with large rubber balls as yielding units. With no resistance the transmission will operate, through an over-running clutch, without slipping. As the resistance increases, the balls are compressed and the driven speed is reduced.

Motor trucking is being done on a large scale in Germany, according to Mr. Fisher. Large six-wheel trucks are used with two or three trailers, sometimes carrying a total load of 40 or 50 tons.

Novel Conveyor in German Engine Factory

The travelers visited the Deutz plant in Cologne, which has an output of 1400 gasoline and Diesel engines per month. The plant uses an assembly line and builds either a gasoline engine or a Diesel engine on the same crankcase. Gasoline formerly cost nearly $1 per gal., but now the price is between 20 and 30 cents. The result is a smaller demand for the Diesel engines and a larger demand for the gasoline engines, relatively.

German engine manufacturers are finding difficulty in building gasoline engines that will stand up in motor-coach service, which they say is much more severe than airplane service. They are still trying to use splash lubrication for the connecting-rod bearings for some of those engines.

A conveyor of unusual design was reported, consisting of a long trough supported on levers and oscillated at a speed of about 2500 vibrations per minute. The amplitude of the oscillation is not far from 1/64 in. The vibration is secured from an electric motor having a flywheel that intentionally is made out of balance. This conveyor will move sand or

castings at a uniform speed, and is said to require only one-sixth of the power that would be needed by any other type of conveyor. A number of conveyors of this type were seen in France.

In the development of this conveyor, trouble was found with certain springs. The best alloy springs would last only 90 days. Finally, some plain carbon-steel springs not heat-treated were found that would not break. A by-product of this work was the development of a vibration testing machine that will give comparative results in about 15 min.

Nature Study in Engineering

One of the German engineers who was visited reported observing a salmon in a stream of falling water. From pictures with a motion camera it was impossible to detect any movement of the fish, which was not jumping up the stream but standing motionless in the falling water. How it supported itself in the falling water was a mystery, and this engineer decided that it was done by taking in water through the mouth and expelling it through the gills. This same principle is embodied in the design of a boat having its propeller at the front, drawing in water and expelling it through the sides. It is claimed that this boat can be propelled at a given speed with one-seventh the power required when the propeller is at the rear of the boat. It is proposed to use this same principle in the propulsion of airplanes.

GAS-ELECTRIC MOTORCOACHES

Superior for City Service and Have Low Depreciation, Chicago Section Is Told

Members of the Chicago Section to the number of about 50 met in the Monadnock Building on Tuesday evening, March 13, to hear C. A. Atwell present his paper on Generators and Motors of Gas-Electric Motorcoach Drives, which was so well received at the Pennsylvania Section in February and at the Detroit Section earlier in March. The discussion in Chicago indicated keen interest there also.

A representative of the Canadian Pacific Railroad told the Section members of the attractions of Quebec and her people and urged them to make their hotel and railroad reservations early for the Summer Meeting. Tentative plans are being made to have a special car for Chicago members which will connect with the special train that is to go from Detroit to Quebec.

Chairman F. G. Whittington expressed regret that Otto W. Young, formerly chairman of the Chicago Section, was leaving that district to take up his new duties as chief engineer of the Hyatt Roller Bearing Co.

The report of the Section Nominating Committee was presented by its chairman, Harry F. Bryan. The nominations for Section officers and committee representatives, as reported by the committee and approved by the Section, are as follows: Chairman, J. W. Tierney; vice-chairman, D. P. Barnard; secretary, Lee Oldfield; treasurer, G. A. Buckbee; Nominating Committee, John S. Erskine; alternate, E. W. Stewart; and Sections Committee, F. G. Whittington.

Electric Transmission Superior for City Work

Following the presentation of Mr. Atwell's paper, J. C. A. Straub, of the International Harvester Co., opened the discussion. He said that for weight reduction the generator armature can serve as the flywheel for the engine of a gas-electric vehicle, provided the coupling is not too flexible. For city motorcoach operation Mr. Straub considers the electric transmission supreme, but operators probably will not be willing to pay for such equipment on the longer intercity routes.

In reply to a question, Mr. Atwell said that the battery winding of the field, which is a feature of the generators used, is necessary to obtain a rapid pick-up when the driver steps on the throttle. To increase the engine power by higher speed, a resistance can be placed in the shunt field. Ordinarily this is done by a foot-switch that is used only when extra power is needed. In some applications, for use with skilled operators, a variable resistance can be manipulated to control the speed of the engine for various power requirements. For ordinary driving no such resistance is used.

Discussion of driving connections between the motor and the rear wheels brought the statement from Mr. Straub that the added weight and cost of two worm-drives more than offset the advantage of eliminating the differential where two motors are used. Mr. Atwell believes that the double-reduction gear has a slight advantage over the worm-drive at low speed.

Some Gas-Electric Operating Advantages

Some of these coaches have three systems of braking: hand brakes, air brakes and electric brakes. The electric brake generally supplied is not commonly used as a service brake because it requires training the drivers to prevent too harsh action, according to Mr. Atwell. He said that in some cases the schedule speed has been increased as much as 20 per cent by the use of the electric transmission, because the driver is not fatigued by shifting gears about 3000 times per day. It is impossible to say what the increased engine life will be, but Mr. Atwell considers the service easier because the engine can drop immediately to idling speed when its power is not needed.

R. D. Harrison, of the General Electric Co., said that comparisons had recently been made between 1000 motorcoaches with mechanical and 1000 with electrical transmissions, operated under comparable conditions by various companies in the Country. It was found that the depreciation rate of the mechanical-drive vehicles is computed on the basis of a life of 5 years, while the depreciation for gas-electrics is on the basis of 7.28 years. The average schedule speed is 15-per cent higher with the gas-electrics and the entire maintenance expense is approximately 1½ cents per mile more with the mechanical transmissions. Another fact brought out by this investigation is that the gas-electric coaches have an availability factor of from 90 to 95 per cent. Because of this and the higher schedule speed, seven motorcoaches with electric transmission can replace eight with mechanical transmission; therefore, the total investment is about the same with either type.

COLORADO CLUB HEARS GWYNNE

George R. Gwynne, chief automotive engineer of the Continental Oil Co., presented an address on Supervision of Motor-Vehicle Transportation at Long Distance at a meeting of the S.A.E. Club of Colorado held in Denver on Feb. 28. The next meeting of the Club, for which a topic and speaker were to be selected later, was scheduled for March 20.

Mr. Gwynne's paper, which was accompanied by 120 lantern slides, was the same as the speaker presented at the Transportation Meeting of the Society in Chicago last October. In it the author told of the supervision and maintenance methods followed by the oil company in caring for the motor-vehicles used by it in distributing its refined petroleum products throughout the intermountain and plains States from eastern Washington, Montana and southern South Dakota to Missouri, northern Texas and New Mexico.

The general office automotive department at Denver controls and supervises the whole operating and maintenance system, through seven base shops or divisions located in Denver, Salt Lake City, Butte, Pueblo, Kansas City, Tulsa and Wichita Falls. Traveling inspectors, who make their headquarters at strategic points throughout the vast territory, inspect the vehicles regularly. They carry a complete set of repair tools weighing 250 lb. and can make major repairs in isolated locations. The company is standardizing on as few makes and models of passenger-car, truck and tractor as possible and bases its decisions regarding

these on tests made at its proving ground and on a survey of the number of manufacturer's factory branches that are located in its territory and stocked with replacement parts for distribution.

In conclusion, Mr. Gwynne gave some interesting detail figures of operating and maintenance costs which aggregated $831,571 in 1927 for a total mileage of 4,285,487.

SPOKE BEFORE M.I.T. STUDENT BRANCH

For the primary benefit of the members of the Student Branch of the Society and the aeronautical engineering students at the Massachusetts Institute of Technology, weekly addresses on automotive engineering subjects were given at the Institute on Friday afternoons in March by prominent men in the industry at the invitation of President Samuel W. Stratton. Prof. Charles F. Park and Prof. C. Fayette Taylor, of the Institute, were also much interested in the meetings and lent their support and aid, according to A. L. Darragh, of the Student Branch.

Dr. H. C. Dickinson, of the Bureau of Standards, gave a talk on Research in Automotive Engineering on March 9. The following week William F. Joachim, of the National Advisory Committee for Aeronautics, gave an address on High-Speed Fuel-Injection Engines. On March 30 George J. Mead, of the Pratt & Whitney Aircraft Co., spoke on the Impressions of Commercial Aviation which he gathered on his recent trip to the Pacific Coast over the air-mail routes.

Saying that the fundamental concepts of the Diesel engine are far superior to those of the Otto-cycle engine and that the Diesel engine is one of the most efficient engines ever conceived, Mr. Joachim went on to discuss its advantages. The most important of these, he said, are: mechanical simplicity; absence of need for a carbureter, an ignition system and a magneto; freedom from radio interference; mechanical injection of the fuel; operation on cheap fuel; low fire hazard; and use of the two-cycle principle, with consequent small number of parts and simple mechanism.

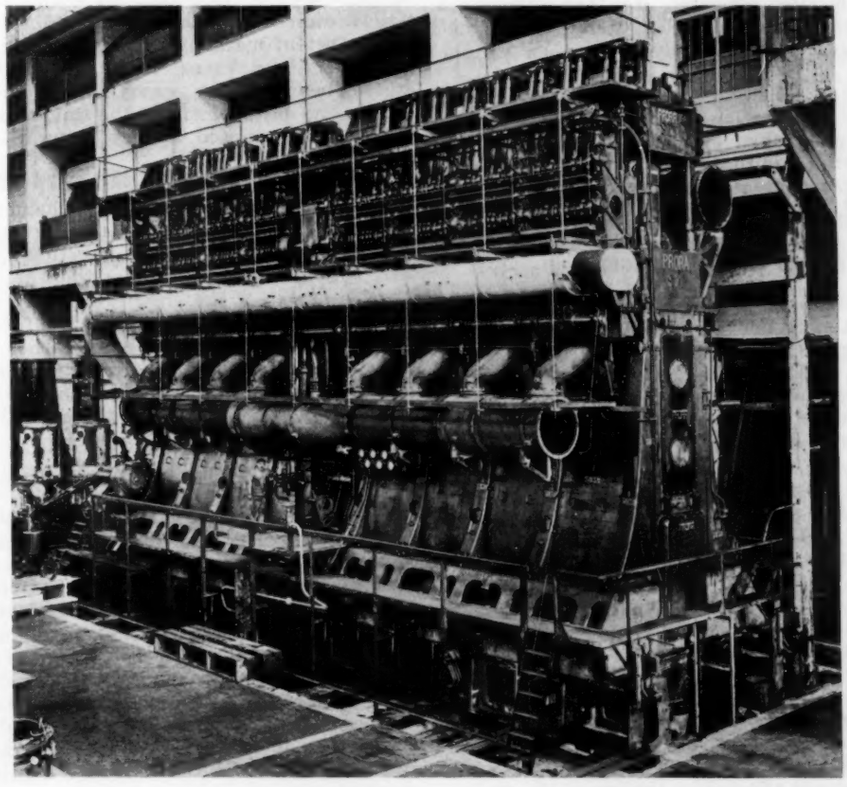
The Institute's 81-ft. wind-tunnel, one of the largest in the world, was moved from a temporary building in February and permanently installed in the new Daniel Guggenheim aeronautical laboratory. This tunnel is nearly 15 ft. in diameter at the ends and 7 ft. in diameter at the observation station. A 14-ft. propeller can create a wind velocity of 90 m.p.h.

A Big Diesel-Engine Meeting

Metropolitan Section Dinner and Technical Session Aboard the Motor-Ship Saturnia Draws a Record Crowd

Two days after landing in New York ought to be a reasonable time for the purser and chef of an ocean liner to prepare a dinner for a salon full of visitors. The Saturnia, of the Cosulich Line, was due at the dock Monday, and A. L. Schoff thought Wednesday, March 28, would be a good time for the Diesel-engine meeting of the Metropolitan Section to be held on board the boat. But one of the cylinder-heads cracked in mid-Atlantic and the boat, which sailed out of Trieste on March 14, had to finish its voyage against head winds with only 8 to 14 of its 16 cylinders working. On Sunday the delay was reported to Mr. Schoff, who was arranging the meeting, and he began to wonder when and where the meeting would be held.

The boat docked finally at 5:30 p.m., Wednesday, and dinner was served to 490 members and guests of the Section, more than 300 of them in the first-class dining-salon and the others in the second-class salon. The dinner was excellent and well served, with just enough Italian character to make it interesting. For instance, in the first dish, labeled "Antipasto all' Italiana," were pickles that were sampled with the courage needed by all good research men. Immediately afterward one guest was heard to remark that he had bitten off the fuse!



ONE OF THE MAIN ENGINES OF THE SATURNIA

In the Finished Boat the View Is Obstructed by Several Grilled Decks That Give Access to the Whole Engine. The Man Near the Center Gives an Idea of the Size of the Engine, Which Is Four Decks High from Base to Top

Of course the dinner was served a little late and there was no time for inspecting the machinery of the boat before dinner, as had been planned. More than 100 guests who had not secured dinner tickets came to the meeting, making what is said to be a record attendance of 600 for a Metropolitan

Section meeting. Among the guests were most of the councilors of the Society, who attended a meeting in New York City the same day, and a number of women, who were entertained at bridge.

In the absence of the chairman, Vice-Chairman Sidney Dresser opened the meeting with a reference to an article in a popular weekly reporting a 32-ft. Diesel-engined boat as one of the leading impressions received at the Motor Boat Show.

Chairman Dresser then introduced Col. W. Guy Wall, president of the Society, who welcomed members of the National Association of Engine and Boat Manufacturers and spoke of the common interests of the Association and the Society and the readiness of the Society to cooperate in standardization and in any other way possible.

Engine and Boat Manufacturers Are Guests

Henry R. Sutphen then spoke for the Association, of which he is president. He said that America can duplicate the engines of the Saturnia. Although it was not generally known, submarines built for the British Government by the Submarine Boat Corporation, of which Mr. Sutphen is vice-president, crossed the North Atlantic in 1916. These were equipped with four-cylinder Diesel engines of American make that developed 36,000 hp. at 115 r.p.m. He spoke of some of the details of the Saturnia engines, particularly the superchargers. He said that a certain amount of additional power can be developed by an engine with a supercharger at about one-half the initial cost of an increase in the size of the engine to produce the same additional power.

Mr. Sutphen made a strong plea for earnest consideration of the problem of reestablishing an American merchant marine. His Association, he said, will welcome close cooperation with the Society.

Chairman Dresser remarked that the way is being pointed out for the Metropolitan Section of the Society to assume a responsibility for coordination between the automotive engineers and the marine builders. He then introduced Giuseppe Cosulich, who welcomed the guests on board what he said was the largest motorship plying between Europe and America.

Mr. Schoff then was called to the chair and expressed appreciation of the cooperation of the officials of the Cosulich Line and called upon Jesse C. Arkerbauer, port engineer of the line, who said that the Cosulich Line selected Diesel engines for this boat after a world-wide investigation, not because of any Diesel-engine hysteria or snap judgment.

Some Details of the Engines

There are two Burmeister & Wain main engines, each with eight double-acting cylinders, 33 1/16 x 59 in. Each engine is 65 ft. long, 40 ft. high and 15 ft. wide. They weigh 820 tons each, and the two-piece crankshafts weigh 128 tons for each engine. Cylinder-heads weigh 7 tons, and a piston and connecting-rod assembly weighs 5 tons. The 20-in. diameter propeller-shafts weigh 18 tons and their liners 3 tons each.

These two engines, the engineers said, develop 10,000 hp. each without, and 12,000 hp. with, the superchargers. The mechanical efficiency is 83 per cent and the thermal efficiency is a little over 39 per cent. The fuel consumption is 0.31 lb. per hp-hr., which may be compared with the 1 lb. per hp-hr. required by the quadruple-expansion steam-engines of the best boats. The maximum engine-speed is 120 r.p.m., and the speed of the boat is 20 knots. These engines are direct-connected to propellers that are 5.3 ft. in diameter and of 5.4-ft. pitch. The fuel can be shut off from the lower ends of the cylinders and the engine will run steadily at 18 r.p.m. The pistons are cooled with lubricating oil and the cylinders with sea water.

Among the great savings effected by the use of the engine are the reduced bunker space and the short time required for bunkering the boat for a transatlantic voyage.

There are several auxiliary engines of a total capacity of 6000 hp. that are direct-connected to generators and air-compressors. These auxiliaries are arranged in units so that some always can be held in reserve, according to Mr. Arkerbauer.

This boat has made two round-trips between Trieste and South America, and this is her second voyage to New York City.

Boost the Merchant Marine

At this point O. D. Treiber was called to the chair as a Diesel-engine expert. He spoke of this as the most important marine meeting ever held by the Society, and renewed Mr. Sutphen's plea for an American merchant marine. America now has no boat to match the Saturnia, he said, and a new merchant marine must be built around the Diesel engine. Before the Civil War America led on the sea, and during the World War there were about 680 ship-building concerns at work. Mr. Treiber said that there are now only three private yards in the Country that can build a first-line ship.

H. D. Hill, of the Hill Diesel Engine Co., was introduced as a man who has been building steam engines and other types of engines in the Middle West for many years. Mr. Hill said that the Diesel engine is now in the position occupied by the gas engine 25 years ago, when buyers expected little but engine failure and would send to the factory, when they could not start their engine, for a service man who might find nothing worse than an empty gasoline tank or a dead battery. Soon local "experts" appeared. They generally would re-time the valves and tell the owner how the engine should have been built, but they would get it running and the builders owe much to their work.

Americans are still suspicious of Diesel engines and throw up their hands at the first sign of trouble, according to Mr. Hill. Some blame is due to engine makers who promise too much. In spite of the greater competition, it is easier to sell Diesel engines in Europe, partly because engines there are operated by well-qualified engineers who are willing to follow directions. The Diesel engine should be in the care of competent mechanics the same as any other piece of fine machinery, and it must be fed with oil that at least is clean.

The next speaker was C. L. Cummins, who recounted briefly the development of the Cummins engine as described in his paper printed in The Journal for October, 1927, p. 388.

A new development announced by Mr. Treiber was the improved form of a turbulence chamber in the top of the piston. Trouble had been encountered because of carbon closing some of the minute injection-openings in the cylinder. From this new chamber there issues, during the combustion stroke of the engine, a supply of pure air, directed toward the injection openings. The force of this jet is sufficient to mechanically loosen the carbon, and the air jet also has the effect of burning away the carbon. Mr. Cummins showed diagrams illustrating this and the operation of the injection mechanism of his engines, and also showed several photographs of complete engines.

What Will the Steam Engineers Do?

Prof. C. E. Lucke, of Columbia University, who was the last speaker, presented a paper in which he stated that economic competition is especially strong in transportation. When any new machine threatens to displace an older one, an attempt is made to improve the older machine to meet the competition. Marine steam-engines may be expected to show the results of such a reaction, but they must yield at least a part of the field to the Diesel engine.

At present Diesel engines are more expensive than steam engines and their economic field is in long voyages with short stops at ports. For a boat that is at sea only a relatively small part of the time, the higher cost of the Diesel engine is not warranted.

The difference between a Diesel engine and a gasoline engine was said by Professor Lucke to be that the former is designed to utilize available fuel, while the latter must have

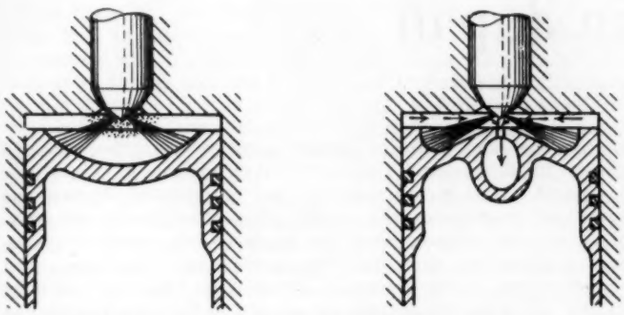


DIAGRAM OF CUMMINS TURBULENCE CHAMBER

The Drawing at the Left Shows the Form of the Combustion Space of Recent Cummins Engines. The Form Creates a Zone of Very Rich Mixture and Poor Combustion, Resulting in Sooting and the Stoppage of Some Spray Nozzles. The Chamber, in the Piston Shown at the Right, Causes a Jet of Air To Be Directed on the Spray Nozzle during the Combustion Stroke, Blowing Off Carbon and Causing Complete Combustion at This Vital Point

its fuel designed for it. He expects a Diesel engine to weigh 30 per cent more than a gasoline engine, but it may be developed to be lighter. The cost should be in proportion to the weight, and the durability of the Diesel should be greater because of freedom from oil dilution. The competitive strength of the Diesel engine will depend, Dr. Lucke believes, on the accuracy with which its fuel can be handled in quantities corresponding to about 1/10,000 of the cylinder volume.

At the conclusion of the meeting an opportunity was given for those who do not hold the curfew law in high respect to visit the engine-room. From B deck, where the meeting was held, it is two decks down to the top of the engines. The bottom of the engines is four decks lower. The various grilled-steel decks and stairways accommodated many visitors who looked over the main and auxiliary engines, one of which was running to furnish lights for the ship.

DETROIT ORGANIZES AIR DIVISION

L. M. Woolson Elected Chairman and W. C. Naylor Elected Head of the Papers Committee

Over 350 Detroit air-minded engineers, members and guests of the Detroit Section organized the Aeronautic Division of the Section on Feb. 27 at the Book-Cadillac Hotel. The meeting, called by Chairman Fishleigh for the purpose of putting up to the aeronautical engineers in Detroit the question of whether an Aeronautic Division, similar to the Detroit Section Body Division, should be organized, resulted in a dinner attendance of 250 and the meeting attendance of over 350.

The unexpectedly large attendance, in spite of the fact that no regular speakers or entertainment had been announced, indicates the intense interest in aeronautical matters.

The purpose of the Division, as outlined by Mr. Fishleigh, is to make it possible for engineers to hold meetings at which aeronautical matters will be discussed from a technical rather than from a popular standpoint. As expressed by Ralph Upson, it would be a Division of engineers, for engineers and by engineers.

Among those who discussed the importance of the proposed organization were Past-President John H. Hunt, L. M. Woolson, who is Second Vice-President representing aeronautics, Ivan Driggs, Ralph Upson, W. C. Naylor, Carl Betts, J. T. Whitaker, B. J. Lemon, W. E. Lay, Major Henkle, Seth Klein, P. Altman and A. J. Underwood.

Silent tribute was paid to Harry Brooks, whose death had only shortly before been reported, as he had been intending to speak at the meeting.

A telegram from President W. G. Wall was read in which he stated that the aeronautic work of the Detroit Section is of great importance and that the Section's progressive ideas are an excellent example to the Society and to the other Sections.

The election of the Division Chairman and the Chairman of the Papers Committee was by ballot. Capt. L. M. Woolson, aeronautical and research engineer of the Packard Motor Car Co., was elected Chairman of the Division and William C. Naylor, chief engineer of the Stinson Aircraft Corporation, was elected Chairman of the Papers Committee. Captain Woolson appointed Messrs. Driggs, Stout, Upson, and Whitaker as members of the Papers Committee and immediately following the session the Committee held its first meeting, the Detroit Division Aeronautic Meeting, which will be held at the time of the All-American Aircraft Show on April 17 and 18, being outlined. The final plans for this meeting are given on p. 487.

During the election of officers Mr. Fishleigh called for suggestions from the floor as to subjects that should be discussed at Division meetings, the many suggestions again indicating the lively interest in highly technical aircraft matters.

As chairman of the Aeronautic Division, Captain Woolson will be a Vice-Chairman of the Detroit Section and Mr. Naylor, as chairman of the Papers Committee, will be a member of the Detroit Section Governing Committee. Notices of Division meetings will go to all Detroit Section members.

Advertising and Prosperity

PRODUCTION is not an activity coaxed hesitatingly from one small venture to another by a well-expressed and limited demand; it is a headlong and wilful plunger, hoping to win a big stake in the business of prophecy as applied on a sweeping scale and backed by ample resources. Consumption is no longer a thing of needs, but a matter of choices freely exercised. The consumer's dollar is not a coin wholly mortgaged to the necessary task of providing a bare living. It has in it a generous segment to be spent at the consumer's own option as to what he will buy, when he will buy, and where.

To come into this sort of an economic situation and attempt to control the consumer's expenditures, in a measure, by telling him about merchandise for sale may be superfluous, it may even at times be unjustified; but if these messages about any specific goods are true, if the goods are worthy, and if the conveying of the message helps the consumer to choose more wisely, the worst that can be said of the practice is that it is "one more influence," and it may be a veritable godsend in a Babel of urgency.

Advertising research is a form of market research; it could not have developed in an age of underproduction, and it would find meager material in a market made up of marginal consumers. But in present conditions of production and consumption there is room for unbiased knowledge of the workings of this force for the modification of demand. And it is this which advertising research is called upon to produce.

The responsibilities of advertising research are the responsibilities falling on any research: to find the truth no matter how obscure, to recognize it no matter in what strange form it may present itself, to formulate it honestly, to state it unmistakably, and to reason from it remorselessly and without regard to prejudices.—From an address by Paul T. Cherington before the Harvard School of Business Administration.

Research in Japan

FROM the time of her awakening until 5 years ago, Japan was utterly dependent upon an imported technology, and her industries were honeycombed with foreign advisers, foreign methods, and foreign research. Today, the situation is vastly different. Japan has almost completely thrown off the yoke of foreign influence. She now has her own research institutions and her own Japanese methods produced by her own technicians. The 30,000 engineers upon the membership rolls of her national engineering societies are but a single evidence of the bulwark with which Japan protects the integrity of her industrial development. She has 93 research laboratories, supported by the Imperial Government, prefectures, municipalities, and private companies, for the operation of which more than $4,000,000 is expended annually. In these outposts on the Japanese industrial frontier, the best that her foreign observers have culled from the experience of Western nations is combined with the products of her own research for adaptation to conditions in the Island Empire.

Most important and best equipped of the research organizations in Japan is the National Institute of Physical and Chemical Research. Founded 10 years ago with a fund of about $3,500,000, it now compares favorably in housing, equipment, and organization with the foremost research organizations in other parts of the world: our own Bureau of Standards, the National Physical Laboratory in England, and the Kaiser Wilhelm Institute in Germany. It has a personnel of 300, 112 of whom are technicians actually engaged in working out many varied problems in both pure and applied science.

The Tokyo Industrial Research Laboratory is perhaps more intimately concerned with the problems of the industries than are the other government-supported organizations. The Institute is divided into five sections, including: chemical analyses; sections dealing with oils, wax, cellulose, wood, pigment, and non-metallic substances; a section for cement, tile building-material; one for coal-tar derivatives and dye stuffs and their applications in industry; and a fifth specifically charged with researches in iron and steel, mechanical testing, reinforced-concrete structures, and electroplating.

It must be remembered that Japan has attained her place in the economic sun in decades; other countries reached theirs in centuries. I should not hestitate to place her in fourth place in the organization of research among the industrial nations of the world, after considering the relative amounts appropriated for research, the number of research agencies, their housing, equipment, personnel, and organization. Only Germany, America and England surpass Japan. It will undoubtedly be argued with some vehemence that Japan has had her industrial pioneering done for her by others. To me it seems that the assimilation of our civilization by a people who are as racially and temperamentally alien to us as the Japanese is as deserving of credit as is our own development.

The Japanese people possess one fundamental quality necessary for success in research—an inquiring mind and a hunger for knowledge. No opportunity is lost by any Japanese in any station of life to come in contact with foreigners and to acquire as much new knowledge as the opportunity affords. Great care is taken to make a detailed record of newly acquired facts, and little time is lost in their application. The similarity between the national organization of research in Japan and the German system does not end here. There is in Japanese research workers that same thorough, painstaking patience in method and also the same skill and deftness in technique which have characterized the preeminent position of the Germans in research.

In general, the trend of research in Japan is toward an economical utilization of natural resources and a refinement of industrial processes, the substitution of cheaper materials, and the mass-production of articles which can be sold cheaply at home and abroad, rather than an organized effort to produce original processes or technique through scientific research.

Japan will soon make herself felt in commerce. The battle for the commercial and industrial supremacy of the nations is already shifting from the West to the East, and I predict that in 10 years the battleground for this titanic struggle will be removed to the Pacific area.—Maurice Holland, director, division of engineering and industrial research, National Research Council, in *The Technology Review*.

Human Engineering

THE art of human engineering is one of the oldest arts in existence in its underlying principles, but it is one of the newest in its recognition as a science in industry. Human engineering is really of the same nature as mechanical engineering in that it arrives at the solution of its problems in much the same way.

But when we step out of the mechanical realm into the realm of human relations, what a contrast there is! How imperfect our efforts are! What a difference there is between the confident, efficient way in which we go ahead in mechanical engineering and our blundering in the realm of human engineering.

To be successful in human engineering, we must do just what we do in engineering of the other sort. In mechanical engineering, if you are going to design in steel, you begin by treating steel as steel. You find out the principles that govern it; when these are determined, you can forget the material and think only of these principles. Now, the first essential of human engineering is being willing and able to treat men as men. This is the first step toward finding out the principles that govern the employment of men in useful tasks. When we have determined these principles, we may then go ahead with confidence.

The first essential in the treatment of men as men is to remember that the all-important thing about man is his power to think. The welfare of the man is more important than tools or machinery. The appeal of human engineering is always to a man's mind.

Organization, to be most effective, must have a common objective; one which all the units of the organization see and understand; and this objective should be so coupled with individual benefit and group benefit as to furnish the most powerful incentive toward individual and group effort. This is simply the adoption of the principle of right as the unerring law of action; and we all acknowledge that the right way gives us the right-of-way. When causes are right, effects take care of themselves.

Men are much more precious material than steel: Is it too much to ask that a human organization be built with the same scrupulous attention to principle that governs a well-designed locomotive?

In organization discipline, again, the human engineer can

learn from his mechanical brother. Here is an untrained man who is taken into a mill as an oiler. Partly through ignorance and partly through carelessness, he permits dust and sand to get into the bearings of a shaft that is running under a heavy load at a high speed. Before long the bearing is running hot. Suppose that the engineer in charge gives the oiler a cursing, "riding" him harder and harder until the man loses his self-control. For the time being he is reduced to the animal; he has ceased to be a thinking, reasoning being. That engineer, in doing this, has done exactly what the man whom he is reproving did, and under circumstances which rendered it far more blameworthy. He has put sand into the bearings of an important human relationship. He has increased friction where he should have avoided it. Suppose that, instead of merely scolding, he patiently instructs. In so doing, he raises the man higher than he was; he builds up his character.

We must have "humanics as well as mechanics," which means, in plain words, treating men as men, not as machines.

The most important engineering course today is human engineering, and fellowship is its basis. For, if a man knows all there is to know about business and all other human activities, and has not fellowship, that he may work for and with others harmoniously, how can he utilize what he knows?

Human engineering is one of the most important factors in reducing labor turnover. It teaches that you cannot receive anything with a closed hand—you must open up first. —Clarence H. Howard, president, Commonwealth Steel Co., in Metropolitan Life Insurance Co.'s Executives Service Bulletin.

Eugene Dickinson Burnell

THE unexpected death of Eugene Dickinson Burnell, vice-president of the Overman Cushion Tire Co. and a resident of New York City, occurred at Atlantic City on Feb. 21 as the result of cerebral hemorrhages. Funeral services were held in Atlantic City on Feb. 22 and interment was at Woodlawn Cemetery, New York City. Mr. Burnell is survived by his parents, Dr. and Mrs. A. T. Burnell, of Los Angeles, and by his wife and three sisters.

Mr. Burnell was aged 43 years, having been born in 1884 at Seattle, and had been an Associate Member of the Society since 1921. He was graduated in 1906 by the college of civil engineering of Cornell University, with the degree of civil engineer, and was a member of the American Society of Civil Engineers and of the American Society of Mechanical Engineers.

During the 13 years from 1906 to 1919 Mr. Burnell was engaged in the designing, constructing and operating of numerous important civil engineering projects. As assistant engineer for Hugh L. Cooper & Co. he assisted from 1906 to 1908 in the designing of hydroelectric and steam powerplants. In 1909 he was designing engineer for the Isthmian Canal Commission and designed locks and machinery in the Canal Zone. As resident engineer and construction superintendent for the J. G. White Co., from 1910 to 1913, he was engaged in the designing and constructing of powerplants, dams and harbor work. He supervised construction of steam railroads in 1914 for the Power Construction Co., of Shelburne Falls, Mass. The following year, serving in the same capacity for the Northern Construction Co., of Winnipeg, he had charge of the construction of 100 miles of concrete water-supply aqueduct. During the war Mr. Burnell was chief engineer and works manager first for the Evans Engineering Corporation and then for the Atlantic Loading Co., both of New York City, and was engaged in the designing, constructing and operating of munition and shell-loading plants. His next peace-time industrial activity was the investigating of business conditions as assistant district manager for the Foundation Co. In 1921 he became assistant to the president of the Overman Cushion Tire Co. and assumed the president's duties on sales, finance and production.

Mr. Burnell was well known not only in engineering circles, but socially, being a member of the Cornell University, the Rod and Gun, and the Rockwood Hall Country Clubs.

C. H. Smith

AS THE result of a fall at the Pittsburgh Athletic Club, C. H. Smith, president and general manager of the Westinghouse Union Battery Co., died suddenly on Feb. 22. He had just returned from Florida, leaving his family in the South, and was staying at the club for a few days prior to starting on a contemplated business trip to the Pacific Coast.

Mr. Smith had been identified in executive capacities with the Westinghouse interests for more than 25 years, was known as an authority on cost accounting and was prominent in the National councils of many business organizations.

Born at Jefferson, Pa., in 1872, he attended the public schools and, during 1895 and 1896, the Curry Business College in Pittsburgh. His first business connection was as stenographer to the managing editor of the *Pittsburgh Daily News*. From this he went to the Westinghouse Electric & Mfg. Co. for 3 years and, after an absence of a year, entered the service of the Westinghouse Air Brake Co. in 1900 in the correspondence and order department. In a few years he became head of this department, and later was promoted to the position of assistant to the general manager. In 1916 he supervised important war-contract work carried on by the company at Providence, R. I., and in 1917 was appointed assistant to the president. In 1919 he was made director of clerical operations of the Westinghouse Air Brake Co. and its many subsidiaries, including the Union Switch & Signal Co., the American Brake Co., the National Brake & Electric Co., and the Locomotive Stoker Co. His direction of these operations continued even after he was made vice-president and general manager of the Westinghouse Union Battery Co. in 1924.

It was in this year that Mr. Smith was elected to the Society, with the grade of Associate Member. At the time of his death he was a member also of the National Association of Cost Accountants, the National Battery Manufacturers Association, the American Management Association, the American Statistical Association, the Pittsburgh Chamber of Commerce, the Automobile Club of Pittsburgh, the Keystone Athletic Club, the Pittsburgh Athletic Association, the Edgewood Country Club, and several fraternal orders.

Applicants for Membership

The applications for membership received between Feb. 15 and March 15, 1928, are listed below The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

AFLAGUE, MANUEL, assistant superintendent of production engineering, American Car & Foundry Motors Co., *Detroit.*

ALEXANDER, J. FLOYD, service manager, Bradshaw Motor Co., *Dallas, Tex.*

ALFARO, HERACLIO, consulting aeronautical engineer, 2440 Overlook Road, *Cleveland Heights, Ohio.*

BAUER, CHARLES A., chief development engineer, Indian Motocycle Co., *Springfield, Mass.*

BENNETT, JAMES C., manager of automotive department, Associated Oil Co., *San Francisco.*

BERRY, CHARLES H., storekeeper, division of highways, Department of Public Works, *North Hollywood, Cal.*

BISBEE, D. P., designer, Robert Thompson Co., *Los Angeles.*

BIXLER, MARSHALL HAYNES, general manager, Fremont Metal Body Co., *Fremont, Ohio.*

BLACKISTON, JAMES T., instructor, Southern Junior High School, *Baltimore.*

BLOCK, WILLIAM O., automobile body art designer, Ford Motor Co., *Dearborn, Mich.*

BLOOMFIELD, JOHN J., laboratory assistant, Studebaker Corporation of America, *South Bend, Ind.*

BOWLES, CLAUDE A., plant equipment engineer, Chrysler Motor Corporation, *Highland Park, Mich.*

BRETT, HENRY, JR., development manager, Kelly-Springfield Tire Co., *Cumberland, Md.*

BRYAN, JOHN CLIFFORD, balloon and airship school, Air Corps, *Scott Field, Belleville, Ill.*

CARNEY, T., assistant engine engineer, Willys-Overland Co., *Toledo.*

CARSON, A. E., sales service engineer, Delco-Remy Corporation, *Anderson, Ind.*

COLLADAY, EDWARD E., factory training work, Buick Motor Co., *Flint, Mich.*

COOPER, JAMES J., service engineer, U. S. Aluminum Co., *Cleveland.*

CORBETT, C. M., general garage foreman and assistant superintendent of automotive equipment, Louisiana Oil Refining Corporation, *Shreveport, La.*

CURTS, ROBERT M., engineer, New Jersey Zinc Co., *Palmerton, Pa.*

DARLING, EDGAR WILLIAM, draftsman, Rolls-Royce of America, Inc., *Springfield, Mass.*

DINSMORE, CLARENCE B., instrument development, A.C. Spark Plug Co., *Flint, Mich.*

DOELLING, HANS ALFRED, factory superintendent, De La Vergne Machine Co., *New York City.*

DREBING, ELMER CHARLES, master mechanic, Calumet Coal Co., *South Chicago, Ill.*

DYE, KENNETH R., assistant engineer, Murray Corporation of America, *Detroit.*

FAGER, E. P., chief chemist, Dearborn Chemical Co., *Chicago.*

FORBES, DUNCAN P., metallurgist, Rockford Malleable Iron Works, *Rockford, Ill.*

GANDAIS, MARIS, draftsman, American Car & Foundry Motors Co., *Detroit.*

GARDINER, CLIFFORD ATWOOD, manager, C. M. Lovested & Co., Inc., *Manila, P. I.*

GOVE, CARL S., service manager, Henshaw Motor Co., *Allston, Mass.*

GUTTERSEN, ERNEST L., vice-president, Willhelm Oil Co., *St. Paul, Minn.*

HEINS, JOHN J., chief installation engineer, John Warren Watson Co., *Philadelphia.*

HERRON, MILO D., vice-president and general manager, Graham-Paige Co. of Washington, D. C., *City of Washington.*

HOPKINS, HOWE H., draftsman, Nash Engineering Co., *South Norwalk, Conn.*

HOPWOOD, CHARLES E., draftsman, Consolidated Gas, Electric Light & Power Co., *Baltimore.*

HUBERT, CLARENCE A., draftsman, Hall-Scott Motor Car Co., *Berkeley, Cal.*

INGHAM, EDWARD S., manager of service and retail sales, Budd Wheel Co., *Detroit.*

JOHNSON, GEORGE D., partner, Gas & Oil Engine Service Co., *Long Island City, N. Y.*

JORGENSON, L. W., shop superintendent, Motor Coach Co., *Lomita, Cal.*

KELLEY, JOHN P., sales manager, A. O. Smith Corporation, *Milwaukee.*

KERBY, FLOYD GEORGE, Detroit body engineering representative, Studebaker Corporation of America, *Detroit.*

KICHERER, HARRY JAY, mechanical engineer and works manager, Marquette Co., *Minneapolis.*

LAMOTTE, JOHN W., experimental road engineer, White Motor Co., *Cleveland.*

LAUER, RODNEY E., chief draftsman, LeBaron-Detroit Co., *Detroit.*

LUKENS, H. M., draftsman, Graham-Paige Motors Corporation, *Detroit.*

MACKIE, ROBERT ADAM, body design and layout draftsman, American Car & Foundry Motors Co., *Detroit.*

MILLER, C. C., layout, Studebaker Corporation of America, *Detroit.*

MOONEY, C. N., district service manager, White Co., *Newark, N. J.*

MORSE, HERBERT G., electrical engineer, General Electric Co., *Schenectady, N. Y.*

MORSS, CHARLES ANTHONY, engineer, Wright Aeronautical Corporation, *Paterson, N. J.*

MORVAY, ANTON ALLAN, airplane engineer and designer and chief engineer, American Aircraft Corporation, *Chicago.*

MUHLBACH, HERMAN, C., mechanical engineer, International Motor Co., *Glenbrook, Conn.*

NARDONE, ROMEO M., draftsman and designer, Eclipse Machine Co., *East Orange, N. J.*

NADOR, EMERY N., engine designer, Ford Motor Co., *Dearborn, Mich.*

NEFF, RUSSELL M., Detroit Steel Products Co., *Detroit.*

NORTH, CHARLES HECTOR, teacher, Hamilton Junior High School, *San Francisco.*

PORTIER, R. E., chief mechanic, Los Angeles agency, Union Ice Co., *Los Angeles.*

PRATHER, GEORGE W., inventor and owner, Prather Mfg. Co., *Santa Cruz, Cal.*

QUASE, CARL O., 430 South Catherine Avenue, *La Grange, Ill.*

REINER, JOHN, president, John Reiner & Co., Inc., *New York City.*

RICHARDS, C. O., assistant body engineer, Cadillac Motor Car Co., *Detroit.*

RICHARDS, JOHN P., layout and design, American Car & Foundry Motors Co., *Detroit.*

RIPPE, CHARLES E., body detailer, Ford Motor Co., *Dearborn, Mich.*

RITTER, JACOB J., sales and engineering, New Britain Machine Co., *New Britain, Conn.*

RODERICK, JAMES J., assistant to district engineer, Westinghouse Airbrake Co., *New York City.*

SAGER, RUSSEL, experimental work on gears and cams, General Motors Corporation, *Detroit.*

SAVANE, JOHN W., supervisor of supplies and motor vehicles, Long Island area, New York Telephone Co., *Brooklyn, N. Y.*

SENKOWSKI, ALEXANDER, assistant technical manager, Polish Skoda Works, *Warsaw, Poland.*

SHUMAKER, CAPT. FLOYD N., U. S. A., Air Corps, Lowry Field, *Denver.*

SNELL, WARREN UTLEY, experimental designer, Humfrey-Sandberg Co., *London S. W. 1, England.*

SOLOMON, LOUIS J., layout man, Studebaker Corporation of America, *Detroit.*

STEPHENSON, THOMAS WILLIAM, automobile body draftsman and detailer, Ford Motor Co., *Dearborn, Mich.*

STONE, BERNARD S., 2007 Third Avenue, *Detroit.*

SWANEY, C. S., regional mechanic, Standard Oil Co. of California, *Pomona, Cal.*

VAN ZANDT, STEPHEN J., aeronautic engineer, Ford Motor Co., *Dearborn, Mich.*

VOILES, OSCAR MONROE, superintendent, LeBaron-Detroit Co., *Detroit.*

WASMER, CHARLES L., president, Cleveland Wrought Products Co., *Cleveland.*

WEDEKIND, JOSEPH CHARLES, mechanical draftsman, Studebaker Corporation of America, *Detroit.*

WIGHTMAN, WILLIAM B., supervisor of vehicular equipment, Bakeries Service Corporation, *Kansas City, Mo.*

WILSON, JAMES MATTHEW, draftsman, LeBaron-Detroit Co., *Detroit.*

WOINA, BENJAMIN A., engineer, Budd Mfg. Co., *Detroit.*

WOYDT, EDWARD, mechanical engineer, White Motor Co., *Cleveland.*

WRIGHT, LEWIS A., assistant patent counsel, Packard Motor Car Co., *Detroit.*

WRIGHT, ROBERT A. LEA, service manager, Overseas Motor Proprietary, Ltd., *Melbourne, Victoria, Australia.*

YOKOI, YOSHINOSUKE, chief engineer in airplane engine department, Nagoya Arsenal, *Atsuta, Nagoya, Japan.*

ZANZINGER, GEORGE H., superintendent of motor-vehicles, Bell Telephone Co. of Pennsylvania, *Philadelphia.*

Applicants Qualified

The following applicants have qualified for admission to the Society between Feb. 10 and March 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ATLAS DROP FORGE CO. (Aff) 209 West Mount Hope Avenue, *Lansing, Mich.;* Goodnow, E. W., secretary.

BAILEY, S. R. (A) production manager, Bailey Mfg. Co., 32 High Street, *Amesbury, Mass.*

BALZ, OTTO (M) foreign manager and president of New York Branch, Hahn & Kolb, Stuttgart, Germany; (mail) 572 West 173rd Street, *New York City.*

BARR, MAJOR ROBERT SHERMAN, U. S. A. (S M) Ordnance Department, City of Washington; (mail) 714 Southern Railway Building, *Cincinnati.*

BAXLEY, C. HERBERT (M) instructor in mechanical engineering and head of mechanical laboratory, Pratt Institute, *Brooklyn, N. Y.;* (mail) 152 Steuben Street.

BECK, C. H. (M) general sales manager, Westinghouse Air Brake Co., *Wilmerding, Pa.*

CANDEE, A. H. (M) manager of gas-electric traction section of general engineering department, Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.*

CARLSON, ALEXANDER (M) vice-president and general manager, Dietrich, Inc., 1331 Holden Avenue, *Detroit.*

CRAMER, W. J. (A) superintendent, General Piston Ring Co., Maple Street and Nickel Plate Railroad, *Tipton, Ind.*

DAVIS, GILBERT W. (A) standards department, Durant Motor Co. of New Jersey, Newark Avenue, *Elizabeth, N. J.*

DOUGHERTY, CHARLES M. (A) assistant chief inspector, Stutz Motor Car Co. of America, Inc., 830 North Capitol Avenue, *Indianapolis.*

DUNSTON, WILLARD J. (A) general foreman, Packard Motor Car Co., Allston, Mass.; (mail) 13 Greene Street, *Somerville, Mass.*

EMMONS, W. H. (J) factory inspector, Braden Steel & Winch Co., 3 North Madison Street, *Tulsa, Okla.*

FARNSWORTH, SIDNEY W. (M) president, K. P. Products Co., Inc., 60 Beaver Street, *New York City.*

GAIRING, EMIL (M) president, Gairing Tool Co., 19 West Woodbridge Street, *Detroit.*

GLASPER, FRED (A) assistant general foreman, Lycoming Mfg. Co., 768 West Fourth Street, *Williamsport, Pa.*

GRAHAM, JOHN R. (A) service manager, Thornton-Fuller Automobile Co., *Philadelphia;* (mail) 621 Old Haverford Road.

HICKEY, GEORGE N. (M) engineer, Kermath Mfg. Co., 5890 Commonwealth Avenue, *Detroit.*

HUF, HARRY F. (J) senior research chemist in charge of automotive laboratory, Atlantic Refining Co., 3144 Passyunk Avenue, *Philadelphia.*

LEAHY, M. J. (M) consultant in mechanical and chemical engineering, 1901 W. T. Waggoner Building, *Fort Worth, Tex.*

LEEDS, NORMAN, JR. (A) sales engineer, Raybestos Co., *Bridgeport, Conn.*

LONG, C. ELMER (J) junior draftsman, General Motors Truck Co., Pontiac, Mich.; (mail) Box 68, R. F. D. 4, *Birmingham, Mich.*

MATHIESON, A. C. (M) chief draftsman in automotive-brake division, Westinghouse Air Brake Co., 418 Roup Street, *Pittsburgh.*

MUENZE, LEO H. (M) superintendent, Pure Oil Co., Brooklyn, N. Y.; (mail) 108-02 Metropolitan Avenue, *Forest Hills, N. Y.*

MUNN, M. D. (M) repair service engineer, White Co., 842 East 79th Street, *Cleveland.*

NELAN, JAMES R. (M) superintendent of shops, Los Angeles County Road Department, Los Angeles; (mail) P. O. Box 338, *Baldwin Park, Cal.*

ODELL, HERBERT B. (A) proprietor and manager, Canadian Beaver Co., 571 Gerrard Street, East, *Toronto, Ont., Canada.*

OLMSTED, C. E. (M) vice-president in charge of pipe line, manufacturing, engineering and marine departments, California Petroleum Corporation, 936 Security Bldg., *Los Angeles.*

PARKER, PHILIP S. (J) engineer, care of Thomas Cook & Son, Berkeley Street, Piccadilly, *London W. 1, England.*

PHILLIPS, CARL M. (M) body designer and engineer, Hayes-Hunt Corporation, 961 Newark Avenue, *Elizabeth, N. J.*

RICHTER, ELMER W. (A) draftsman and technical adviser in works engineering department, Oxweld Acetylene Co., *Newark, N. J.;* (mail) 284 Meeker Avenue.

RIGBY, JOSEPH (A) foreman automobile mechanic, Carr Bros., *Seattle;* (mail) 314 East Harrison Street.

ROBERTS, CHARLES P. (M) instructor in mechanical engineering, Robinson Laboratory, Ohio State University, *Columbus, Ohio.*

ROSENBAUM, WALTER (A) vice-president and general superintendent, Rosenbaum Co., Sixth Street, *Pittsburgh.*

STEIN, JOHN ALBERT (A) foreman of shops, division of highways, Department of Public Works, *Redding, Cal.;* (mail) 1221 California Street.

STEPHENS, J. T. (M) superintendent of transportation, Schulze Baking Co., *Chicago;* (mail) 8320 South Marshfield Avenue.

STEWART, PETER (M) test engineer, Hyatt Bearing division of the General Motors Corporation, P. O. Box 476, *Harrison, N. J.*

STROMBERG, AUSTIN W. (A) editor, Power Wagon Publishing Co., 536 Lake Shore Drive, *Chicago.*

SUPY, M. FORD (A) district service manager, Studebaker Corporation of America, South Bend, Ind.; (mail) Studebaker Corporation of America, *Atlanta, Ga.*

TEXAS PACIFIC COAL & OIL CO. (Aff) 1710 Fort Worth National Bank, *Fort Worth, Tex.;* Lederer, E. R., vice-president.

VAN DEUSEN, CAPTAIN E. S., U. S. A. (S M) Quartermaster Corps, City of Washington; (mail) 548 Church Street, *Ann Arbor, Mich.*

VAN WAGNER, ALTON J. (M) sales engineer, Vacuum Oil Co., Detroit; (mail) 341 James Street, *Grand Rapids, Mich.*

WALLACE, EDWARD S. (M) mechanical engineer, Chevrolet Motor Co., *Detroit.*

WESTCOTT, B. W. (M) research engineer, Zenith Detroit Corporation, *Detroit;* (mail) 221 South Manistique Avenue.

WHITE, A. BLYTH (J) inspector of automotive equipment, Bell Telephone Co. of Canada, *Montreal, Que., Canada;* (mail) 6289 Casgrain Street.

A PORTION OF THE OLD FORTIFICATIONS AT QUEBEC

Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B. Body; C. Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

All the World's Aircraft. By C. G. Grey and Leonard Bridgman. Published by Sampson, Low, Marston & Co., Ltd., London. 466 pp. [A-1]

As a record of one of aviation's "wonder years," this volume is more bulky and full of information than its similar predecessors. With them it forms a chain of historical accounts of the civil, military and technical development of aeronautics. The historical section constitutes the major portion of the book, listing for each country the aeronautical societies and publications, outlining the army and navy air services, and summarizing the major occurrences in the field of aviation during the year. Other sections give brief descriptions of the current makes of airplane, aircraft engine and airship manufactured in each country.

Interest attaches to the volume because of its comprehensiveness, no less than 51 countries being represented in it. Efforts have been made to obtain the information from the best authorities in each nation. In the case of the French air service, the data requested could not be obtained directly from the authorities, hence the exposition of the French air forces has been made by an English observer, and it is said to be the most detailed account of the French system ever published, covering both the military and the naval branches.

Kinematographic Studies in Aeordynamics. By Alexander Klemin. Published in *Mechanical Engineering*, March, 1928, p. 217. [A-1]

Of the two photographic methods, striæ and shadow, the Aeronautical Research Institute of the Tokyo Imperial University seems to have favored the former in its development of high-speed photography. The first step, after discarding the usual shutter method of kinematography, was to use the striæ method with periodic sparks of short duration as the light source. Successful results were obtained with a high-frequency generator giving a light source of regular intervals of about 1/950 to 1/1200 sec.

To obtain even higher speeds a new method based on the striæ principle was developed. This involves the use of a constant source of light and a rotating series of mirror-like surfaces, which reflect the images on a rotating cylinder film. Exposures are made at the rate of 2100 or 3000 per sec. ordinarily, and have reached, in one instance, a speed of 20,000 per sec.

In addition to describing the general development work, this article incorporates examples of the photographs taken.

The Design of Airplane Wing-Beams. By Joseph S. Newell. Published in *Proceedings of the American Society of Civil Engineers*, March, 1928, p. 725. [A-1]

This paper presents the method developed by the Army Air Corps for the analysis and design of the beams used in airplane wings. Part 1 presents, in the form developed by the author, the formulas now used for obtaining the stresses in wing-beams under various types of loading, emphasis being placed on those for the uniformly distributed and the concentrated transverse loads acting in conjunction with an axial compression. Tables of functions in radians are included to reduce the labor of applying the formulas. A graphical method is also given, which, however, has only limited application.

Part 2 is devoted to a description of the method developed by the Forest Products Laboratory for computing the allowable stresses on wooden beams of various shapes when subjected to transverse loads alone or in combination with axial loads. Part 3 presents and discusses the results of several tests made on pin-ended struts both with and without lateral loads. Sufficient tests have been made to prove the dependability of the precise formulas for computing the imposed stresses, but the data on the reliability of the method for obtaining the allowable stresses are meager and do not permit of forming more than a general conclusion. This method is, however, being used by both the Army and Navy Air Services and is recommended by the Air Regulations Division for all commercial airplanes.

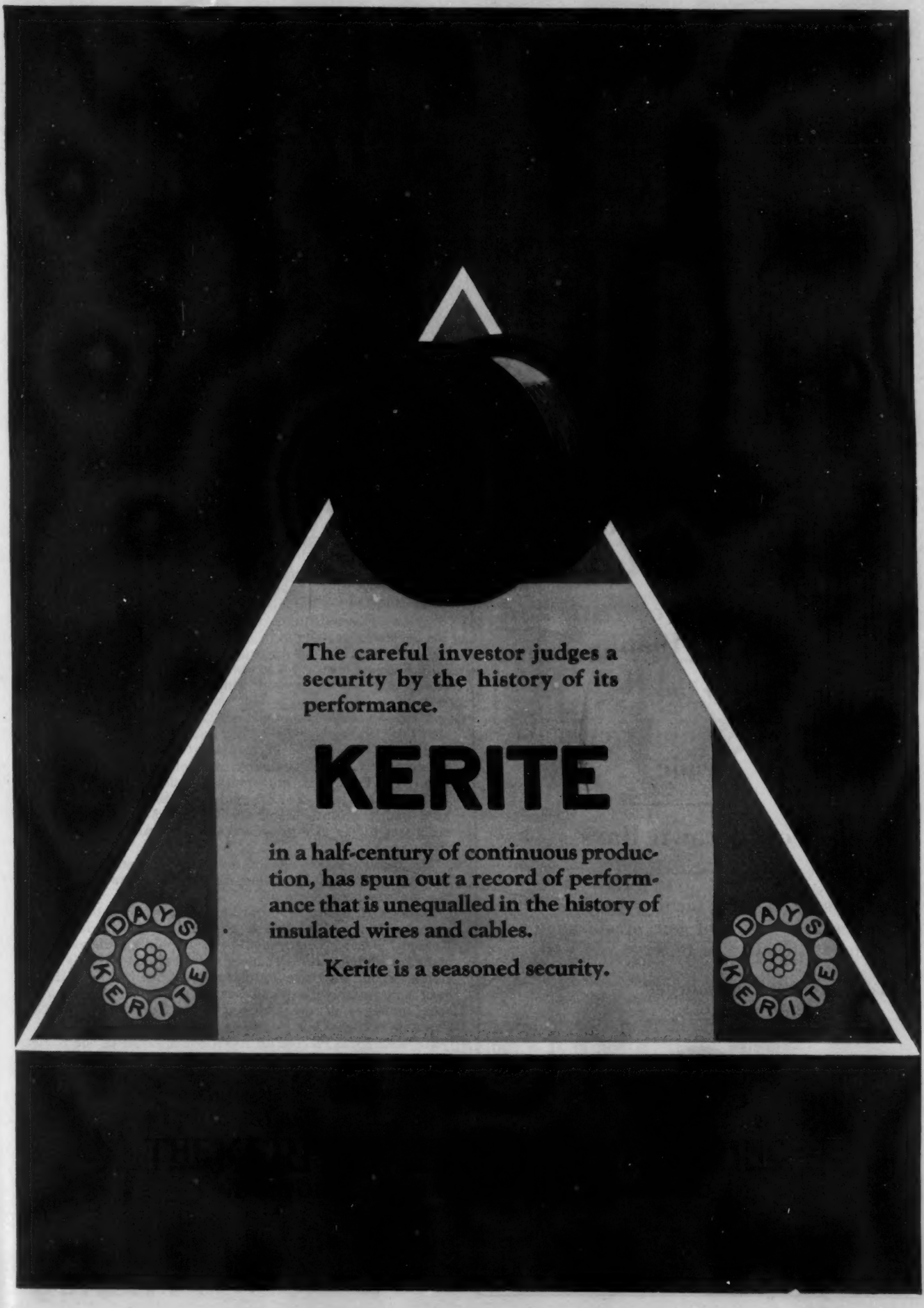
Notes on the Guggenheim Safety Competition. By Alexander Klemin. Published in *Aviation*, Jan. 30, p. 246, and Feb. 6, 1928, p. 314. [A-1]

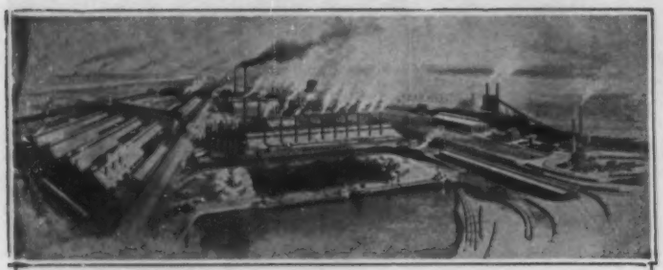
The author, one of the technical advisors of the Daniel Guggenheim Safe Aircraft Competition, presents the material of this article as his personal views. However, his familiarity with the rules will particularly recommend his views to constructors and designers interested in the competition.

Devices to increase maximum lift are discussed, under 13 headings, in the first installment. A large number of tersely stated data are here condensed, while annotations point the way to references giving more detailed information. From his examination of the questions involved, the author concludes that: rear flaps, preferably slotted, can be made to give maximum Ky values of 0.0045 with good efficiency at high speed; the Wragg-type tandem airfoil can be made to secure maximum Ky values of 0.0045 without excessive depression; the Handley-Page front slot in conjunction with the rear slotted flap can be made to increase maximum life powerfully, beyond $Ky = 0.005$; variable camber does not seem worth considering; variable area, *per se*, does not seem a promising line of attack; rotating cylinders, however arranged, are not within the realm of practical possibilities; air ejection is likely to involve prohibitive power losses; and removal of the boundary layer by suction is an extremely powerful line of attack and deserves intensive study.

Suggestions for aerodynamic experimentation on high-lift devices are incorporated in the second installment. An airplane to meet the requirements of the competition, he advises, should have some method of increasing the maximum lift of the airfoil and some method of improving the control beyond that provided by conventional control surfaces. No

(*Continued on p. 26 of advertising section*)


The careful investor judges a security by the history of its performance.
KERITE
in a half-century of continuous production, has spun out a record of performance that is unequalled in the history of insulated wires and cables.
Kerite is a seasoned security.
DAYS KERITE
DAYS KERITE



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ALLOY and CARBON STEELS

Made to S. A. E. Standard Specifications

Die Rolled Parts

such as

Rear Axles, Drive Shafts and Forging Blanks

for the

Automotive and General Trade

Cold Drawn Bars

Our every modern facility, coupled with the earnest desire of our organization to cooperate, enables us to serve you well.

Your inquiries are solicited.

QUALITY D SERVICE

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Works and General Offices, Buffalo, N. Y.

New York: Equitable Bldg. Cleveland: Union Trust Bldg.
Philadelphia: Morris Bldg. San Francisco: Call Bldg.
Detroit: General Motors Bldg. Milwaukee: Wisc. National Bank Bldg.

Personal Notes of the Members

(*Continued from p.* 408)

the B. D. Parker Co. in the capacity of tractor expert. After receiving the degree of bachelor of science in mechanical engineering from the University of Colorado in 1924, he was professor of mechanical engineering at the University of Arizona, teaching machine and automobile design and having charge of the oil research laboratory and the dynamometer test room. Upon receiving the degree of master of science in mechanical engineering in 1927, he returned to his work in the oil industry. Mr. Leahy was elected a Member of the Society in 1927.

J. H. Shoemaker, who has been a member of the sales organization of the Gabriel Snubber Mfg. Co. for about a year, has been made sales manager in charge of distribution.

Prior to his present connection, Mr. Shoemaker was associated successively with the Ericson Mfg. Co., the Westinghouse Union Battery Co., the Allyne-Zerk Co., the Perfection Heater & Mfg. Co. and the Swan Carburetor Co., resigning as distribution manager of the last-named company to enter the service of the Gabriel Snubber Mfg. Co.

Mr. Shoemaker was elected tc Associate membership in the Society in 1919. He has been at different times a member of the Buffalo Section and the Detroit Section and is now a member of the Cleveland Section.

George A. Buckbee has resigned his position as Chicago sales representative of the Gurney Division, Marlin-Rockwell Corporation, to accept a position with the Hyatt Roller Bearing Co., Chicago.

Mr. Buckbee has been connected with the bearing industry for the last 15 years, with the exception of 2 years of military service, having been associated successively with the Fafnir Bearing Co., the Ahlberg Bearing Co., the Bearing Service Co., and Standard Steel & Bearings, Inc., prior to his becoming salesman, in 1922, for the Gurney Ball Bearing Co. He has been an Associate Member of the Society since 1922 and has been for 5 years a member of the Chicago Section, being at the present time the treasurer of the Section.

Earle V. Hennecke has recently formed a company which will do a National distributing business and also give sales and advertising counsel to manufacturers of automotive products. The new company, with offices at 247 Park Avenue, New York City, will operate under the name of Earle V. Hennecke, Inc. For 10 years Mr. Hennecke was associated with the Moto Meter Co., Inc., and at the time of his resignation was vice-president and general manager of that company.

Mr. Hennecke was elected to Associate membership in the Society in 1924, and has been for several years a member of the Metropolitan Section.

William E. Kemp, who until recently was Eastern distributer for Byrne, Kingston & Co., Kokomo Electric Co. and Kokomo Brass Works, has been appointed district sales manager of Kingston Products Corporation, which is a consolidation of the three companies just mentioned. He has been connected with these interests for 18 years, having been manager of the Chicago, New York City and New England branches.

Mr. Kemp was elected an Associate Member of the Society in 1914 and was transferred to Member grade in 1927. An active member of the Metropolitan Section for more than 10 years, he has served the Section as Vice-Chairman and as Chairman.

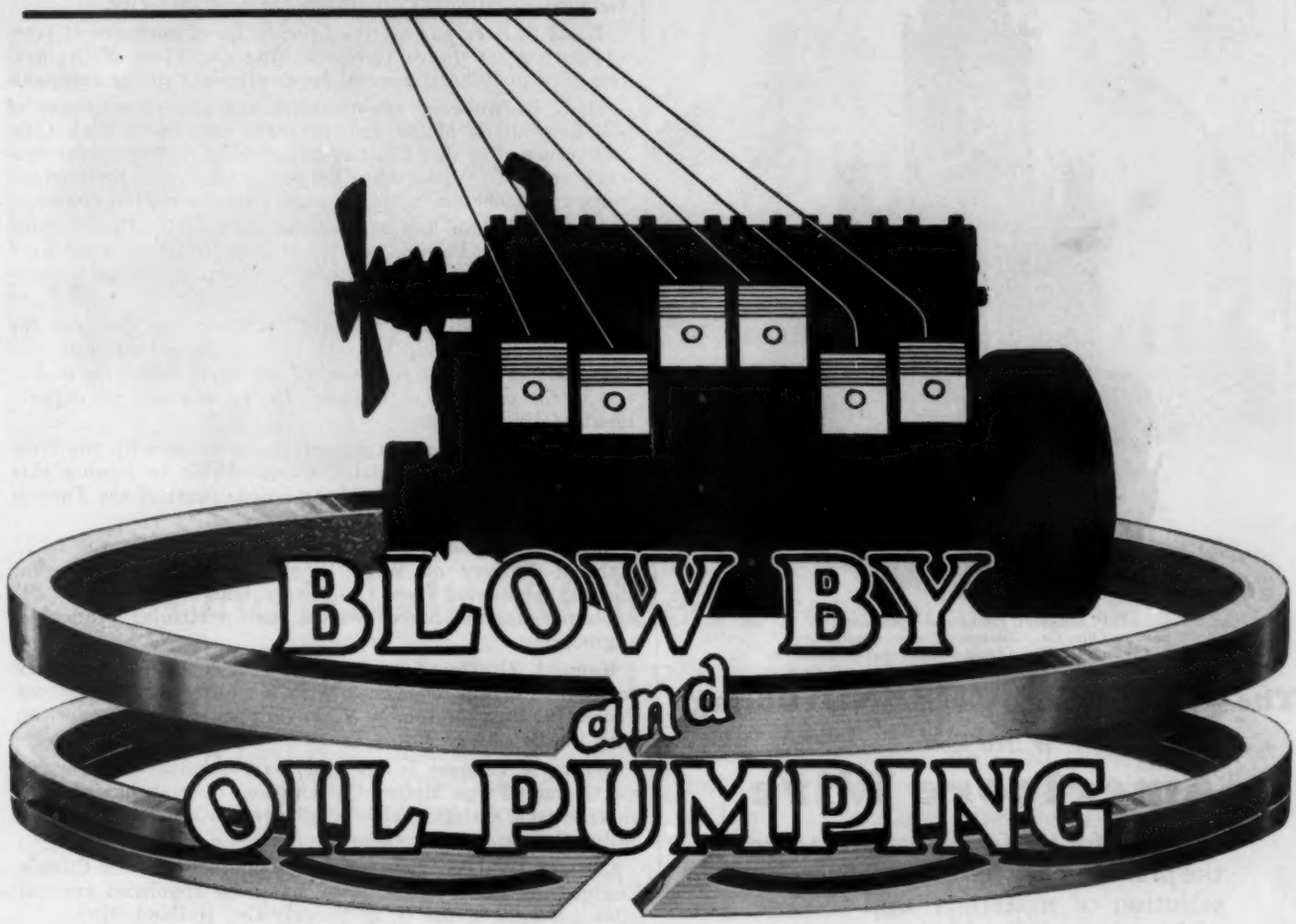
Mr. Kemp has rendered invaluable service in the work of various committees of the Society.

L. H. Amrine has accepted a position as sales manager for the Imperial Molded Products Corporation, Chicago. He was previously special representative for the Dallas Brass & Copper Co., also of Chicago.

Fred G. Baender was made development engineer for the De Laval Separator Co., Poughkeepsie, N. Y. Prior to making this connection he was designing engineer for the Mack Truck Co., Long Island City, N. Y.

(*Continued on p.* 20)

There are eighteen or more chances in every six cylinder engine for "Blow By" and "Oil Pumping"



THIS fault is so common and the remedy so obvious.

But in these days of high compression, force lubrication and increased speed, correcting "blow by and oil pumping" presents a problem which requires the best in piston ring installation.

Piston Rings must be absolutely accurate; sizes must be correct; the grain of the metal must be uniform and of just the right hardness. A ring that is short lived or will not retain a constant tension under extremely trying conditions falls far short of correcting a fault that *Good Rings Can Correct.*

The Quality-Drainoil combination is designed, cast and finished to eliminate "Blow By and Oil Pumping." It is not a "trick" remedy nor is it a cheapened price product. Quality Brand rings are manufactured for a mechanical purpose *which they accomplish.*

The Piston Ring Company

Muskegon, Michigan

QUALITY **DRAINOIL**

American Steel & Wire Company

F. P. Dinkelberg, Chicago—*Architect*
Starrett-Dilks Co., Chicago—*General Contractors*
L. K. Comstock & Co., Chicago—*Electrical Contractors*

The PURE OIL BUILDING • Chicago

Wired with

Americore Wire

Building for the future, as well as for the present, calls for the most careful selection of materials, and the use of Americore Wire in the great new Pure Oil Building, on Wacker Drive, Chicago, is another impressive tribute to the efficiency and permanence of this well-known wire.

For more than a quarter of a century Americore Wire has constantly built its nation-wide reputation for uniform quality, correct design and long service. It can be specified with certainty that it will meet any requirements placed upon it.

Let us send you our indexed catalog and handbook of electrical wires and cables. Estimates furnished promptly from any of our offices in all the principal cities.

SALES OFFICES

CHICAGO	208 So. La Salle Street	NEW YORK	30 Church Street
CLEVELAND	Rockefeller Building	BOSTON	Statler Building
DETROIT	Foot of First Street	PITTSBURGH	Frick Building
CINCINNATI	Union Trust Building	PHILADELPHIA	Widener Building
MINNEAPOLIS—ST. PAUL	Merchants Nat'l Bank Bldg., St. Paul	ATLANTA	101 Marietta Street
		WORCESTER	94 Grove Street
ST. LOUIS	506 Olive Street	BALTIMORE	32 So. Charles St.
KANSAS CITY	417 Grand Avenue	BUFFALO	670 Ellicott Street
OKLAHOMA CITY	First Nat'l Bank Bldg.	WILKES-BARRE	Miners Bank Bldg.
BIRMINGHAM	Brown-Marx Bldg.	*SAN FRANCISCO	Russ Bldg.
MEMPHIS	Union and Planters Bank Bldg.	*LOS ANGELES	3987 E. Slauson Ave.
DALLAS	Praetorian Building	*PORTLAND	777 Nicolai St.
DENVER	First National Bank Bldg.	*SEATTLE	4th Ave. So., & Conn. St.
SALT LAKE CITY	Walker Bank Bldg.	*United States Steel Products Company	

Personal Notes of the Members

Continued

Ph. Baldauf, Jr., who was formerly body engineer for the Sayers & Scoville Co., Cincinnati, is chief engineer for the General Woodwork Corporation, also of that city.

Louis B. Berg has assumed the duties of manager of manufacturing for the A. C. Spark Plug Co., Flint, Mich., having previously been general superintendent of the company.

H. L. Brownback, vice-president and general manager of the Brownback Motor Laboratories, Inc., New York City, has returned to this Country after being in France for several months. While there he was engaged in development work in connection with the new Anzani aviation engine.

R. C. Callahan has become associated with the Oakland Motor Car Co., Pontiac, Mich. He was formerly a research engineer of the General Motors Corporation Research Laboratory, Detroit.

Frederic Canali, who was until recently tool designer for the Ford Motor Co., Detroit, is now connected with the Hupp Motor Car Corporation, of the same city. He is acting in the capacity of designer in the engineering department of this company.

Robert E. Clingan has accepted a position with the New Departure Mfg. Co., Bristol, Conn. Prior to joining this company he was manager of the Toledo plant of the Timken Roller Bearing Co., Canton, Ohio.

James R. Crandall is now ceramic engineer for the D. E. McNicol Pottery of West Virginia, Clarksburg, W. Va. He was graduated from Ohio State University on Dec. 21, having completed his course in that particular branch of engineering.

Kenneth G. Crawford recently returned to his former position of layout draftsman with the Larrabee-Deyo Motor Truck Co., Binghamton, N. Y., having severed his connection with the Brockway Motor Truck Co., Cortland, N. Y.

George A. Delaney is now chief experimental engineer for the Graham-Paige Motors Corporation, Detroit, having previously been assistant chief engineer for the Paige-Detroit Motor Car Co., of the same city.

Lorimer Dunlevy, formerly sales manager of the Climax Engineering Co., Clinton, Iowa, has been appointed general sales manager of the O. E. Szekely Co., Holland, Mich.

O. E. Fishburn, who until recently was chief engineer for the J. W. Murray Mfg. Co., Detroit, has accepted a position as experimental engineer for the Warner Gear Co., Muncie, Ind.

Jack Frost has resigned as field engineer and sales manager of the Detroit branch of the Willis-Jones Machinery Co., Seattle. No announcement has been made regarding his future plans.

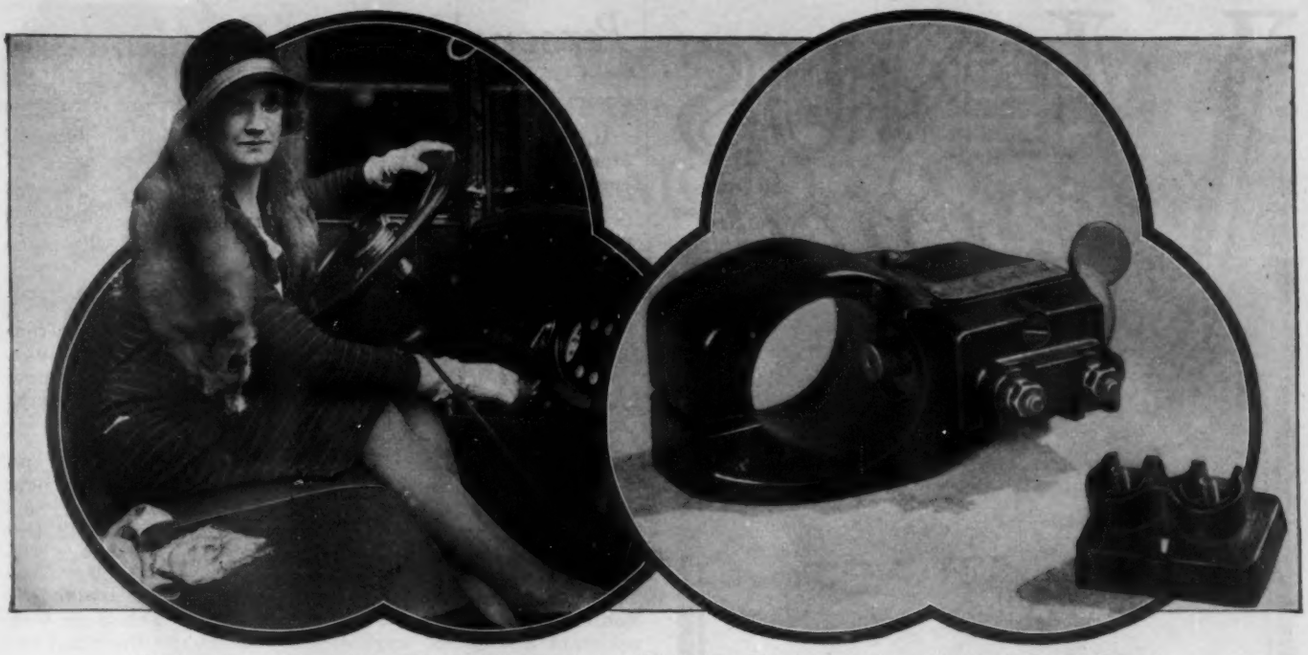
John P. Gaty became associated with the Acoustic Products Co., New York City, on Feb. 14, with duties as research and design engineer. His prior business connection was that of mechanical engineer for the Premier Laboratory Co., also of New York City.

L. H. Gilmer, who has been president of the L. H. Gilmer Co., Tacony, Philadelphia, since its organization in 1904, was recently made chairman of the board of directors of that company. He is succeeded as president by **John S. Krauss,** who has been connected with the Gilmer Company for a number of years in various capacities, and prior to the election was vice-president and general manager.

Leo V. Grogan, previously service manager for the Automobile Sales Co., Memphis, Tenn., has joined the sales department of the Forest Park Electric Co., Springfield, Mass. In connection with his duties in this department he will act as estimater.

Frederick L. Green, who until recently was tool engineer for the Olds Motor Works, Lansing, Mich., now holds a position in the General Motors Corporation Research Laboratory, Detroit.

(*Concluded on p. 24*)



Hershey Coincidental Lock with Bakelite Molded switch body. Standard equipment on all Studebaker cars. Made by Hershey Manufacturing Co., Chicago, Ill.

One Bakelite Molded Press operation completes forty switch bodies

WHEN volume output is demanded, multiple cavity molds effect striking economies. The Bakelite Molded switch body of the Hershey Coincidental Lock, pictured above, is an excellent example of the type of part which may be formed by the multiple process.

The switch body is rather complicated in design and two metal inserts must be firmly embedded during the molding operation. Through the use of Bakelite Molded, forty of these parts are formed in a single press operation, each one a finished piece, accurate in dimensions and with a lustrous surface that requires no buffing or polishing. The strength, high insulation value and handsome appearance of Bakelite Molded makes it the ideal material for parts such as these.

Bakelite Engineering Service

Intimate knowledge of thousands of varied applications of Bakelite Materials combined with eighteen years' experience in the development of phenol resins for automotive uses provides a valuable background for the cooperation offered by our engineers and research laboratories. Write for Booklet No. 5, "Bakelite Molded."

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THE MATERIAL OF ∞ A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

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The Largest Selling Quality Pencil in the World

Choice of the Professions

THE accuracy with which VENUS Pencils are made—the smooth, durable, dependable lead (in 17 degrees of hardness, each degree running true and uniform always) has made VENUS the ultimate choice of technical men and all others who desire the utmost in pencil quality and service.

The well-known watermark finish distinguishes VENUS Pencils and enables you to identify them readily.

17 Black Degrees—3 Copying

For bold, heavy lines . .	6B-5B-4B-3B
For writing, sketching . .	2B-B-HB-F-H
For clean, fine lines .	2H-3H-4H-5H-6H
For delicate, thin lines . . .	7H-8H-9H
Plain Ends per doz. .	$1.00
Rubber Ends, per doz. .	1.20

At Stationers and Stores throughout the World

American Lead Pencil Company
226 Fifth Avenue New York

Makers of UNIQUE Thin Lead Colored Pencils in 12 colors—$1.00 per dozen

Personal Notes of the Members
Concluded

G. C. Hollandsworth is now connected with the General Motors Truck Co., New York City. Previously he was chief engineer for Reliable Trucks, Inc., Chicago.

John R. Holmes has become sales engineer for the Wheeler-Schebler Carburetor Co., Indianapolis. Prior to joining the forces of this company he was research engineer for the Chandler-Cleveland Motors Corporation, Cleveland.

Major Clinton W. Howard, U.S.A., recently returned from the Philippine Islands, where he was commanding officer of the Air Corps stationed at Camp Nichols, Rizal. He is now chief of the Airplane Branch, located at Wright Field, Dayton, Ohio.

F. E. LaFehr resigned as service school manager for the Chrysler Corporation, Detroit, early this year, and is now connected with the Standard Oil Co. of California, San Francisco, in the capacity of automotive engineer in the lubricating-oil division.

Abbot A. Lane is now power engineer for the Dwight P. Robinson Co., New York City. Previous to Feb. 1 he was assistant mechanical engineer for the Public Service Production Co., Newark, N. J.

Frank J. Lucas, who was formerly connected with the South Works of the J. I. Case Threshing Machine Co., Racine, Wis., is now associated with the J. I. Case Plow Works, Inc., of the same city.

Harry S. Lea has severed his connection with the Yellow Truck & Coach Mfg. Co., Chicago, where he was director of personnel. No announcement has been made regarding his future plans.

Herbert H. Mardus has been appointed purchasing agent and parts manager for De Angelis Bros., Inc., New Brunswick, N. J. He was formerly parts department manager and purchasing agent for Newton A. Barnett, Elizabeth, N. J.

Harry W. Paine, previously head of the automotive department of the Boys' Technical High School, Milwaukee, is now associate professor in charge of vocational education at the University of the City of Toledo, Toledo.

Pierre B. Pendill, who was formerly special engineer for the American Car & Foundry Motors Co., Detroit, has been transferred to the San Francisco branch of the company and is acting in the capacity of sales engineer.

Joseph Rawley, until recently connected with the experimental engineering department of the A. C. Spark Plug Co., Flint, Mich., is now chief draftsman of the Buick Motor Co., also of Flint.

J. Webb Saffold, who has been associated with the Devices Development Co., Cleveland, since 1924, and for the last 2 years as president and general manager, announces a change in the name of the company. Hereafter it will be known as the Saffold Engineering Laboratories and will be located at the same address. Mr. Saffold remains as president and general manager of the company.

Henry W. Sweet has joined the engineering staff of Fuller & Sons Mfg. Co., Kalamazoo, Mich., manufacturer of transmissions. Prior to the change Mr. Sweet was chief engineer of the Brown-Lipe Gear Co., also a manufacturer of transmissions. Mr. Sweet has been a member of the Society since 1917, serving for a number of years on the Transmission Division of the Standards Committee.

Joseph C. W. Van Blerck, who was formerly president of the Joseph Van Blerck Engine Corporation, Plainfield, N. J., announces the organization of Van Blerck Motors, Inc., Red Bank, N. J. He holds the office of president with the new company.

Nothing is apt to cost so much as a bearing that cost so little

Another Automotive Manufacturer that uses SKF bearings as regular equipment

WHITE MOTOR COMPANY

Twelve Years As Regular Equipment Prove Value of the Highest Priced Bearing in the World

FOR over twelve years, SKF Ball Bearings have been used as regular equipment by the White Motor Company. On the Model 50B bus as shown above a total of 12 are used in the transmission, rear axle, front wheels and on the fan.

Long life, quiet and smooth operation, plus a minimum of maintenance are obvious reasons why SKF Ball Bearings prove a paying investment in the automotive field. Their choice by leaders in the industry attests the wisdom of using a world-renowned product of quality.

You men who plan, build, use or pay for machines of any kind, remember this: It costs more to replace a poor bearing than to buy the best one that SKF ever produced. AND SKF ANTI-FRICTION BEARINGS ARE THE HIGHEST PRICED IN THE WORLD.

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SKF Puts the Right Bearing in the Right Place

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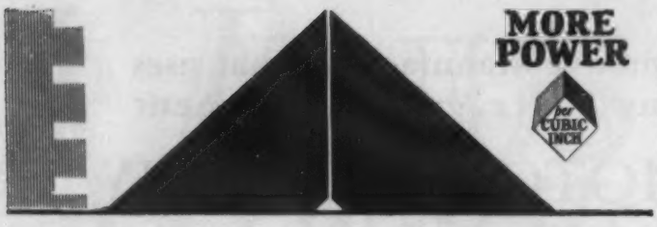

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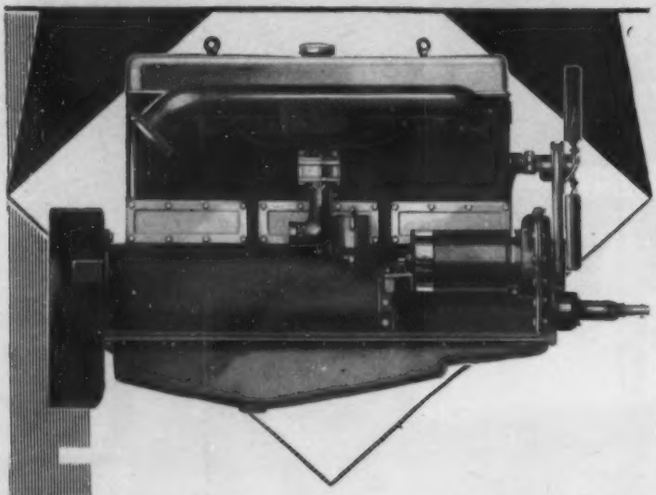

"More Power per Cubic Inch" results from Wisconsin's adherence to engineering principles that are basically correct.

Wisconsin Motors are known throughout the engineering world for their remarkable power output and long-lived, low-cost service.

Busses, trucks, tractors and industrial machinery that are subjected to the brutal strains and stresses of overtime duty need the Wisconsin kind of power plant.

Wisconsin Motor Mfg. Co.
Milwaukee **Wisconsin**

Wisconsin Motors are built in a full line of Sixes and Fours with a power range from 20 to 150 H.P. for Trucks, Busses, Tractors and Construction Machinery.

Notes and Reviews

(*Continued from last page of text section*)

special advantage, the author believes, would accrue from radical departures from the general form of the existing airplane.

Winner of the Schneider Race. Published in *Flight*, Feb. 16, 1928, p. 94. [A-1]

As the winner of the 1927 race for the Schneider Seaplane Trophy, the Supermarine S5, with Napier-Lion racing engine, is one of the most interesting of modern British aircraft. In this article are printed some descriptive details, rather fragmentary, however, due to the withholding of much information. They are said to constitute the first published description of the craft.

The probable Everling high-speed figure is worked out and a comparison made between the S5 and the de Havilland Tiger Moth. The duralumin fuselage was planned with the idea of saving space, and some of the expedients used are here set forth. With a fuselage of such small cross-sectional area as is employed, the gasoline, oil and water systems present many problems, in the solution of which some ingenious features were incorporated. A few of the main characteristics of the craft are listed.

Aerobatics. By Gerhard Fieseler. Published in *Flight*, Jan. 5, 1928, p. 3. [A-4]

"Keep high" is the persistent warning of the author, a Jagdstaffel pilot during the war and since that time a stunt flyer, in this exposition of his technique in executing a number of figures. Crazy-flying, as he calls it, has three values; as an æsthetic exhibition, as a sport and as a method of impressing on the public the air-worthiness of commercial machines.

His own source of guidance in the experiments is not the measurements of stresses, but his "feel" of the airplane. The maneuvers described embrace rolls, keeping the fuselage in a horizontal position; half-loop forward, inverted; downward loop from the upside-down position; closed inverted loop forward; upward loop from upside-down position; vertical figure-of-eight; and vertical figure-of-eight in upside-down position.

BODY

Sheet Steel for Automobile Bodies. Published in *Heat Treating and Forging*, February, 1928, p. 157. [B-5]

Of the total 5,000,000 tons of sheet steel produced yearly in the United States by 30 manufacturing plants, 40 per cent is consumed in the automobile industry. Close cooperation between both industries and a mutual understanding of each other's problems are therefore necessary, so that the seller may supply and the buyer specify the type of material that will best meet the requirements of the consumer.

To supply the information on which such an understanding must be based, the author has planned the present series of articles. The processing of automobile-body sheet steel from the open hearth to finished stamping will be covered. These articles will take into consideration the open hearths used in making a refined steel for sheets, the bar mills, hot mills with their breakdown and finishing rolls, picklers, shears, annealing, normalizing, cold rolling and inspection. All of the discussions will be written in such a way that they can be correlated with their effect on the stamping and appearance of the finished sheet. The material covered will be limited to 16, 18, 19, 20 and 22-gage sheet, which constitute virtually all the gages entering into automobile body manufacture. A short, non-technical chapter on the general metallurgical characteristics of low-carbon steels will be included.

CHASSIS PARTS

Federungsprobleme bei Starren und Schwingenden Hinterachsen. By Erich Marquard. Published in *Der Motorwagen*, Dec. 20, p. 735, and Dec. 31, 1927, p. 755. [C-1]

Is it possible to determine the probable performance of a spring if its static characteristics and those of the chassis

(*Continued on p. 28*)

Resilient as a fine Rapier

To yield stubbornly and yet not break—take thrust for thrust and yet come back—that is true resiliency!

As the cavalier trusted his life to the resiliency of his blade, so may your life be trusted to the resiliency of C G Bumpers.

JUAN RICARDO

CG chromium plated BUMPERS

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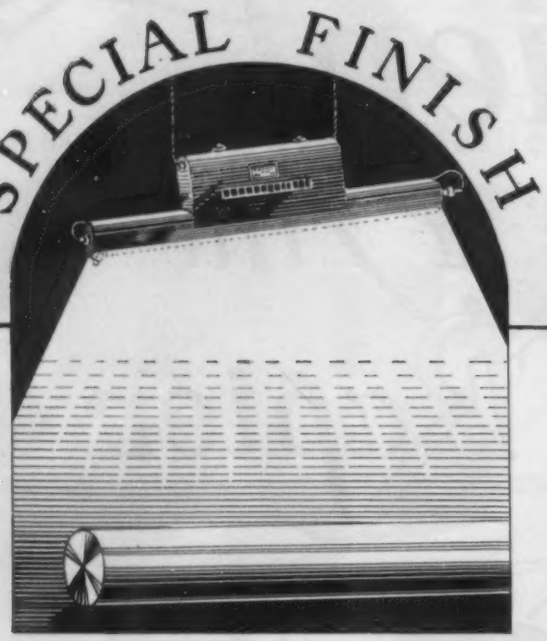
USE·THE·RIGHT·STEEL·FOR·THE RIGHT·PURPOSE



Steel Bars-noted for highest degree *of* surface perfection

UNION Special Finish is accurate in size and true to round but derives its name from the remarkable degree of perfection characterizing its smooth, flawless finish.

The manufacturing method involves the work of centerless grinders and a careful polishing process. The finished bars are finally inspected under Cooper-Hewitt lights where the smallest surface defect could readily be detected.

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Beaver Falls, Pa.

UNION DRAWN STEELS

Notes and Reviews

Continued

with which it is used are known? To the possibilities of such calculations the author devotes the first half of this article. In the second half he applies his conclusions to suspension systems that afford independent oscillation of the wheels by means of axles flexibly mounted or with articulated housings and independent springs for each wheel.

A consideration of the vibrations that occur in the chassis independent of the effect of the road opens the theoretical discussion. Formulas for the calculation of such vibrations are set forth. The disturbances due to road impacts are next considered. The specific problem attacked is to build up calculated vibration diagrams through the use of which experimentally obtained diagrams can be analyzed. Two sets of diagrams are developed; one for the case in which both wheels pass over the same obstacle with the same force, the other for the case in which only one wheel passes over the obstacle. The theoretical section is brought to a conclusion by a brief consideration of shock-absorbers.

In the second, or descriptive, section of the article the unconventional axles of the following makes are dealt with; Rumpler, Tatra, Steyr, Bucciali, Harris-Leon Laisne, Cottin & Desgouttes, Sizaires, Lambda, and Daag.

New Process for Curing Cord Tires and Molded Tubes. By Henry R. Minor. Published in *Industrial and Engineering Chemistry*, March, 1928, p. 291. [C-5]

A new process for the curing of cord tires has been developed and is suggested as a substitute for the air-glycerol and hot-water methods which are said to be subject to certain stated disadvantages. The process consists in first bringing a part of the pressure up to a predetermined point with an inert gas, such as carbon dioxide, then shutting off the gas and turning on steam at the curing pressure and leaving it on through the period of the cure. This combination is said to make it possible to obtain any temperature at any desired pressure always under inert-gas conditions.

Among the advantages claimed for the process are the increase in air-bag life through the use of carbon dioxide, the achieving of certain economies by the substitution of steam for air in maintaining pressure, and general improvement in the product.

ENGINES

Un Procédé de Mesure du Couple Moteur. By Leon Poincaré. Published in *Journal de la Société des Ingénieurs de l'Automobile*, January, 1928, p. 98. [E-1]

The method of measuring engine torque here described has the advantages of being applicable to the engine in the course of its ordinary operation and of giving direct results without complication of outside factors.

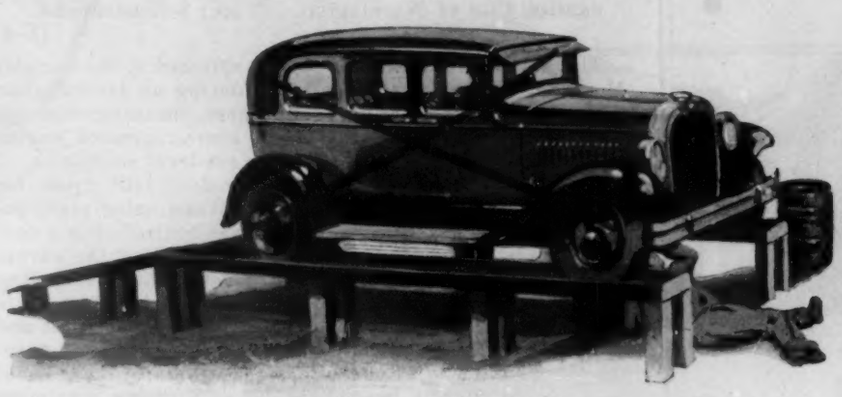
Essential conditions for the use of this method are that between the driving and the driven shafts there is a difference of the speeds of rotation, either a difference in angular speed or a change in direction, and that the shafts are in line with one another. The process consists, briefly, in measuring the torque exerted on the transmission gearcase, which is equal to the difference between the torque measured on the driving shaft and that on the driven shaft.

The transmission gearcase tends to turn around the common axis of both shafts. For the purpose of this method, the principal thing to do is to make the case movable and then fix it with an apparatus which can measure the force necessary to keep it fixed.

The theoretical considerations forming the basis of the method, the possibilities of its application, and a specific scheme being studied by the Farman company are outlined.

The Relative Performance Obtained with Several Methods of Control of an Overcompressed Engine Using Gasoline. By Arthur W. Gardiner and William E. Whedon. National Advisory Committee for Aeronautics Report No. 272.

(*Continued on p.* 30)



Make Oil Draining Unnecessary

If the car owner drains the oil from the crankcase often enough, the engine *may* be protected from the damage caused by dirt, fuel, water, etc. If . . .

But why depend on this uncertain method of protecting the engine? Incidentally, why endanger your prestige as a manufacturer or designer of engines?

Make oil draining unnecessary. Equip every car with the H-W Filtrator before it leaves the plant.

The H-W Filtrator successfully solves the filtration problem because of the following exclusive features:

1. *Non-disintegrating filtering element.*
2. *Automatic cleansing means.*
3. *Solid contamination once removed can never be returned to engine.*
4. *Affords 100 per cent bearing protection.*
5. *Does not contribute to loss of oil pressure, but on the other hand tends to prevent pressure loss as engine mileage is built up.*

Ask our men to bring you the full details.

TRUCK AND BUS OPERATORS

You can now secure Filtrator equipped engines on the following: Hall-Scott, Hercules, Continental, Waukesha, Buda, Wisconsin and Mack

Made by Sheet Steel Products Company

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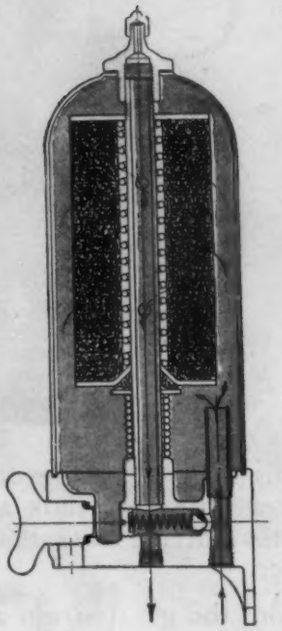
H-W FILTRATOR



Hall-Winslow Patents

Remove the nut, fit compressed air hose to the valve—and the pressure rids the filtering medium of all impurities, which are blown out of the drain opening.

WATSON OIL-RITE SYSTEM

Automotive engineers will be vitally interested in the Watson Oil-Rite System, a new and better lubrication system which easily doubles engine life.

The essential features of the Watson Oil-Rite System are the following:

Keeps lubricant permanently free of abrasives, fuel, acid water, sludge. Applies oil copiously at the initial starting period. Regulates oil supply while running. Heats oil promptly on starting of engine. Keeps oil cooled under top temperature conditions.

Manufactured and sold by

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SHAKEPROOF!

This rugged portrayal of the idea of strength, stress, yank and pull, tells the story of the *only shakeproof* lock washer.

From the great strain and vibration of the heavy automobile chassis, to the vibration of a small heating iron, the first duty of the washer is to make a *permanent* tight connection.

That is absolutely what the Shakeproof Lock Washer does.

Its twisted teeth, set at an angle, and at equal intervals around the diameter —bite deeply into the material as vibration increases.

Plus this big exclusive feature of multiple locking, the Shakeproof Lock Washer is absolutely tangleproof—is easier to handle by workmen—does not mar the work.

"NOT A TANGLE IN A TON."

Type 12 Internal Teeth | Type 15 Countersunk | Type 11 External Teeth

Shakeproof Lock Washer Company

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Send for free shop test samples

Notes and Reviews

Continued

Published by the National Advisory Committee for Aeronautics, City of Washington. 13 pp.; 8 illustrations. [E-4]

This report presents some results obtained at the Langley Memorial Aeronautical Laboratory during an investigation to determine the relative performance characteristics for several methods of control of an overcompressed engine using gasoline and operating under sea-level conditions.

Tests were made at an engine speed of 1400 r.p.m. for compression ratios from 4.0 to 7.6. When using plain domestic aviation gasoline, detonation was controlled to a constant predetermined amount by (*a*) throttling the carbureter, (*b*) maintaining full throttle but greatly retarding the ignition, and (*c*) varying the timing of the inlet valve to reduce the effective compression-ratio. For the first and third methods, the throttle opening and the valve timing, respectively, were adjusted so that the ignition timing could be advanced slightly beyond the advance giving maximum power without exceeding the standard permissible of detonation. The optimum performance for the engine when using a non-detonating fuel, consisting of 80 per cent of commercial benzol and 20 per cent of aviation gasoline was obtained as a basis for comparison.

From these comparative tests, the conclusion is drawn that, of those methods investigated for controlling an overcompressed engine using gasoline under sea-level conditions, maximum power is obtained by maintaining full throttle and greatly retarding the ignition timing. Also, as the fuel consumption, exhaust temperatures, and heat loss to the cooling water are normal, and as this method of control is easily accomplished without adding to the complexity of the powerplant, it may be regarded as the most practicable method for service use.

HIGHWAYS

Construction Methods on Oakland Estuary Tube. By S. W. Gibbs. Published in *Engineering News-Record*, Jan. 19, 1928, p. 100. [F-5]

A subaqueous tunnel that has the largest diameter of any yet constructed is now nearing completion under the estuary between Oakland and Alameda, Cal. It is designed for vehicular and electric-railway traffic, and the efforts put forth to overcome the difficulties opposed by terrain and tide amply testify to the favorable estimation of this type of transportation facility.

Two-thirds of the length of the tube between portals, or 2436 ft., consists of 12 precast concrete segments built in a drydock, floated to the site and then sunk to exact position in a cut previously dug across the estuary bottom and provided with a suitable foundation. The total length of the tube, including approaches, is 4436 ft.

With all precast segments in place, and the tube soon to be completed, this type of construction is said to have proved entirely feasible for locations where an open trench can be maintained in existing water currents, and to cost roughly one-half as much as the common shield method.

MATERIAL

Light Metals and Alloys: Aluminum and Magnesium. Bureau of Standards Circular No. 346. Published by Bureau of Standards, City of Washington. 402 pp.; 115 illustrations. [G-1]

Such great and rapid progress has been made in the metallurgy of a aluminum and its light alloys since 1919, the date of the first issue of this pamphlet, that a revised edition has been imperatively demanded.

Using as a basis valuable recent information resulting from systematic research by Government agencies in this

(*Continued on p. 32*)

Announcing

NEW MODEL "U" STROMBERG CARBURETOR

This latest development of the Stromberg Laboratories has many new and distinctive features which approach the exacting requirements of the modern motorist more closely than any carburetor yet manufactured.

Designed to provide maximum power and speed, as well as extraordinary smooth operation when engine turns over slowly.

The ingenious pump attachment gives that quick, snappy acceleration that is the delight of the modern motorist.

Excellent performance without sacrificing economy in gasoline consumption.

Permit us to give you a demonstration. You will be convinced.

STROMBERG MOTOR DEVICES CO., 58 E. 25th Street, Chicago, Ill.

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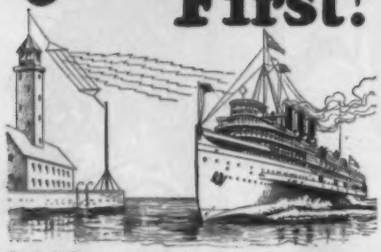
Travel the D&C LAKE LINES
Great Lakes First!



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To Lovers of Sea, Sky and Drifting Clouds:

Summer is just around the corner, and it is in order to suggest a cruise on the Great Lakes as part of your vacation.

We would be pleased to help you plan an outing of two, four, six or eight days' duration on the Lower Lakes, and supply you with pictures and descriptions of pleasant places: Niagara Falls, Mackinac Island, and others.

If you contemplate an automobile tour, plan to make part of the journey by boat. Our overnight service between Buffalo and Detroit; Cleveland and Detroit, is used extensively by automobilists. If you desire a longer voyage our line between Cleveland and Chicago, via Detroit, Mackinac Island and St. Ignace, will appeal to you. Dancing, concerts, radio entertainments, deck games on shipboard—not a dull moment.

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Fares: Buffalo to Detroit, $5; Cleveland to Detroit, $3; meals and berth extra. For the Chicago-Mackinac Island tours fares given are for the round trip, and include every expense on steamers: Buffalo to Mackinac Island, $49; to Chicago, $79. Cleveland to Mackinac Island, $41.50; to Chicago, $71.50. Detroit to Mackinac Island, $30; to Chicago, $60. Stopovers at Mackinac Island and other ports. For reservations, address E. H. McCracken, G. P. A., Detroit and Cleveland Navigation Co., Detroit, Mich.

Fast freight service on all divisions at low rates.

Notes and Reviews

Continued

and other countries and by various individual investigators as reported in technical literature, this circular examines in detail the physical and mechanical properties of aluminum and magnesium and their light alloys. The variation in properties caused by changing the composition of the alloy, by the presence of impurities, by mechanical working, by changes in conditions of manufacturing operations, and by heat-treatment are also given. Equilibrium diagrams for the important alloy systems are presented. Finally, the metallography, corrosion resistance, and methods of protection against corrosion, the theory of heat-treatment, and the application of the alloys to various industries are discussed. The uses of aluminum in aircraft and automobile manufacturing are treated at some length.

Only such data as have passed critical scrutiny are included, and the probable degree of accuracy of the figures quoted is indicated. A guide to a more detailed study is furnished in the extensive and classified bibliography.

The Constitution of Alloys of Aluminum with Silicon and Iron. By A. G. C. Gwyer and H. W. L. Phillips. Published in *Engineering*, Feb. 10, p. 179, and Feb. 17, 1928, p. 210. [G-1]

From time to time the authors have obtained certain anomalous results in their work on aluminum of ordinary commercial purity. These have led to the conclusion that aluminum as cast and as worked is not in structural equilibrium. The authors therefore decided to investigate the conditions and limits of composition determining the appearance of the various constituents, with a view to elucidating any structural changes occurring during the ordinary operations of working and annealing.

A short account of the investigation of the aluminum-silicon alloys has already been published. The present article considers a series of alloys the iron content of which was constant and the silicon content of which varied in steps of 1 per cent from 0 to 4 per cent, of 2 per cent from 4 to 10 per cent, and of 5 per cent from 10 to 30 per cent.

Applying Chromium-Plating for Appearance and Wear. By Frank W. Curtis. Published in *American Machinist*, Feb. 9, 1928, p. 241. [G-1]

An interesting feature of the present article is the pictured representation of the chromium-plating process as applied in various instances. Data are given as to the detail of methods, for instance, for appearance purposes, the deposit is said to be generally between 0.0002 and 0.0005 in.; for wearing qualities, from 0.001 to 0.003 in.; and for the rebuilding of worn surfaces, up to 0.01 in. Deposits up to 0.014 in. can be applied. One among many automotive uses mentioned is the plating of the cylinder-wall with a deposit so thin as not to affect piston fit and yet of sufficient strength to add materially to the life of the parts.

Viscosity of Lubricants under Pressure. By Mayo D. Hersey and Henry Shore. Published in *Mechanical Engineering*, March, 1928, p. 221. [G-1]

The five oils selected for this investigation are believed to be typical of the better-known classes of animal, vegetable, paraffin-base, napthene-base, and blended oils. The maximum pressures and temperatures reached were respectively about 4000 kg. per sq. cm. (57,000 lb. per sq. in.) and 140 deg. cent. (284 deg. fahr.).

Lard oil solidifies abruptly on passing through a critical pressure which, at 22 deg. cent. (71.6 deg. fahr.), is about equal to 1550 kg. per sq. cm. (22,000 lb. per sq. in.). The paraffin-base oil shows a somewhat similar effect. For all of the oils tested except, notably, lard oil, it was found that the temperature coefficient of viscosity is considerably increased under moderately high pressures. These and other facts brought out in the paper may have numerous applica-

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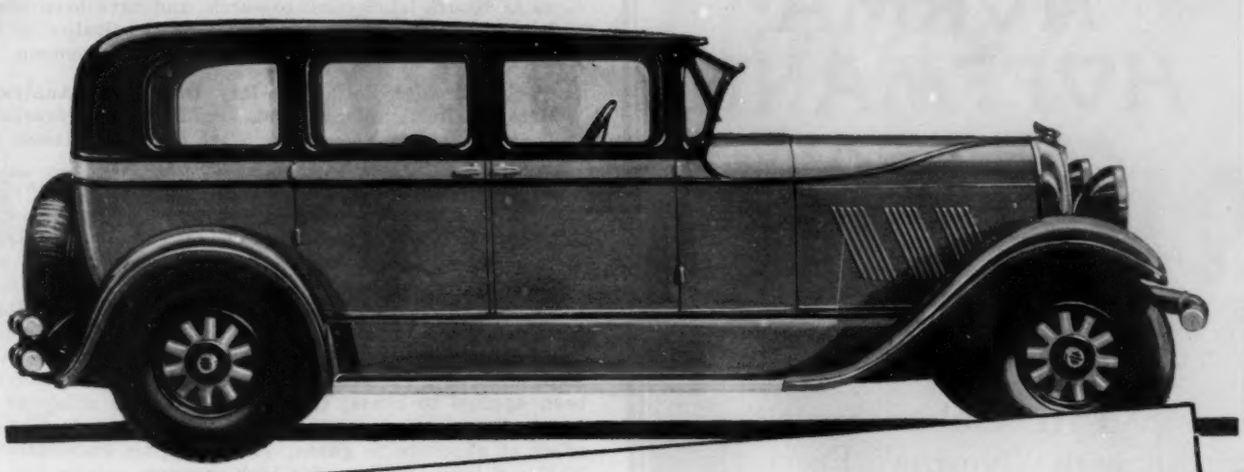

It is true that our chassis lubrication system is used only on Rolls Royce and one other very high priced American car. Anything less perfect and reliable would not measure up to Auburn's high and uncompromising standards.

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AUBURN AUTOMOBILE COMPANY, AUBURN, INDIANA

THE *chassis lubrication system* given such unstinted praise by Auburn is the Bijur System—now standard equipment on all models.

Auburn's adoption of Bijur Lubrication adds another fine car to the increasing number that provide a means of oiling the chassis *daily* from the driver's seat by an operation so simple and convenient that it is never neglected.

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Originators of Modern Chassis Lubrication

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THE results achieved with "Norma" Precision Ball Bearings, with "Hoffmann" Precision Roller Bearings, or with the two in combination, have never yet failed to justify the judgment of the engineers and designers who specified them.

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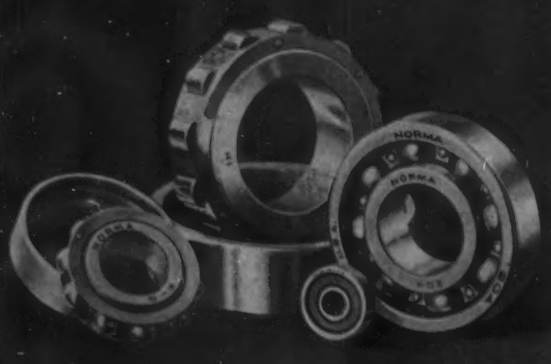

Notes and Reviews

Continued

tions in future lubrication research, and have been thought by the Special Research Committee on Lubrication to be of particular interest in the study of oiliness phenomena.

High-Speed, High-Voltage X-Ray Diffraction Analysis of Metals. By Ancel St. John. Published in *Transactions of the American Society for Steel Treating*, March, 1928, p. 485. [G-5]

A quick and convenient method of X-ray diffraction analysis, particularly adapted for plant control, has been developed. It is a modification of the usual "pinhole" method using tungsten radiation at 200,000 volts, as in radiographing castings, so that a powerful beam passes through ⅛ in. of steel. If desired, entire sheets or formed articles can be mounted in the instruments, or specimens can be cut without affecting the portion to be examined. Exposures of 2 hr. or less are sufficient. The method has been applied to brass, tin and steel in the study of mechanical working, heat-treatment, extrusion, aging and the effect of exposure to gases. Radiographic examination of steel and brass castings for high-pressure service has been carried on simultaneously. Some typical results are illustrated.

Sources of Automotive Fuels. By Frank A. Howard and Robert T. Haslam. Preprint of paper presented before the American Institute of Mining and Metallurgical Engineers, Inc. Published by the American Institute of Mining and Metallurgical Engineers, Inc., New York City. 7 pp. [G-5]

As the one real source of automotive fuel, the authors state, crude petroleum in the world at large was never before in a position so nearly unassailable. Oil-bearing shale is far in excess of any present foreseeable requirement, even if it were compelled to supply the whole automotive market. Through hydrogenation the coal reserves of the world are now also its oil reserves, not directly quantitatively but nearly so.

Besides these three primary sources, any one of them adequate, three secondary sources are present in natural gas, by-products from coal distillation, and fermentation alcohol.

In their preliminary discussion the authors range over a wide field of fuels that could be used for automotive transportation, but concentrate on gasoline as the only one that can provide the type of motive power demanded by the public at a figure low enough to support the industry. Because of the importance of the original cost of the engine and the maintenance and depreciation charges on it, in the total cost of automotive power, the per-gallon price of the fuel is relatively unimportant within wide limits.

An Economic Analysis of the Fuel Oil Situation. By Arthur Knapp. Preprint of paper presented before the American Institute of Mining and Metallurgical Engineers, Inc. Published by the American Institute of Mining and Metallurgical Engineers, Inc., New York City. 6 pp.; 5 illustrations. [G-6]

More than half of the fuel oil marketed in this Country is used by the railroads, the public utilities and as bunker oil, and is sold in competition with coal and gas, not only on a cost basis, but also on the basis of stable markets and long-term contracts. Sales in these three classes are falling off, due to the discouraging attitude of the petroleum industry itself. This attitude has been assumed even though cracking is the only factor tending to decrease the fuel oil supply, the economic balance between outputs and prices of gasoline and fuel oil has never been definitely established, and during the last year the advantage would have lain in selling fuel oil as such rather than cracking it into gasoline.

The future should see real sales effort to find a market for fuel oil in competition with other fuels; it may even find necessary the instituting of research for new uses for

(*Continued on p.* 36)

—at Your Service!

THE 1928 MAGNETO

—modern improvements introduced in Original-Bosch Super-Energy Magneto, meet every modern need.

HERE at last—in the Original-Bosch Super-Energy Magneto is a magneto designed for 1928 performance. Do you require:

—a wide range of operating speeds? The Original-Bosch Super-Energy Magneto gives absolute dependability at the highest speeds. It throttles down to low speeds without shifting gears, yet picks up again smoothly.

—super-energy? This magneto introduces a new principle—the principle of Super-Energy. Notice the increase in engine power, the new agility on hills, the added dependability in performance regardless of loads or roads.

—easy starting? The slow speed performance makes it easy to start with this magneto at hand crank speeds *in below zero weather.*

—freedom from attention and repairs? Its waterproof and dustproof construction, a special aluminum alloy frame instead of a die casting, a high speed interrupter,—these are a few reasons why this magneto protects automotive engines from ignition failures and costly breakdowns. Why, you don't even have to oil this magneto

If you want 1928 magneto efficiency, write for full information about the Original-Bosch Super-Energy Magneto.

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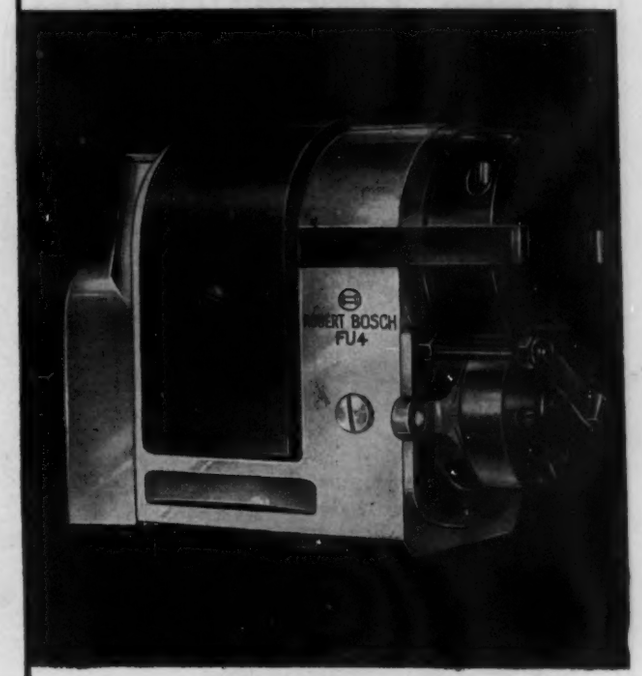

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Just as modern engineering has developed better motors, so has it developed better *Shims*. NATIONAL Shims are *double*-action, and serve a *double* purpose. They improve motor performance by providing a permanent flexible oil seal. They reduce manufacturing cost by minimizing the time and material required for accurate bearing adjustments. Not merely quicker and easier to strip the layers *off* a NATIONAL (because they are already separated and need not be pulled apart with tools). But, if a workman happens to strip off too many leaves, it is just as easy to *put them back*, saving one shim and the time required to fit another. That is NATIONAL *double*-action. That is speed. That is economy. Do they interest you? Submit blueprints for prices. Designs and suggestions by our engineers upon request.

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3. Steel shims 4. Steel bronze-faced shims 5. Steel liners
6. Copper liners 7. Brass liners

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[Double-Action Non-Curling]
SHIMS

Notes and Reviews

Continued

petroleum products, for the heavier oils in particular. Detailed supply-and-demand statistics should form the basis of a better balance in the petroleum industry.

MISCELLANEOUS

Trade Association Activities. By Irving S. Paull, J. W. Millard and James S. Taylor. Domestic Commerce Series No. 20. Published by Bureau of Foreign and Domestic Commerce, City of Washington. 381 pp. [H-4]

A contribution of $35,000,000 a year for industrial research, the maintenance of about 400 university fellowships, yearly expenditures of $3,000,000 for standardization, $10,000,000 for commercial advertising, and the production of the majority of the business statistics available today are a few of the measurements that indicate the importance of trade associations in industrial life.

Since their first appearance just after the Civil War, these organizations have grown in complexity, stability, size, variety and importance of function until they are today given distinct recognition both by industry and by governments. General information on such bodies and specific details about associations in 10 major divisions of industry are presented in this second issue of a handbook for trade association secretaries, the first edition of which appeared in 1923.

Some of the general topics covered are: methods of organization; statistics; legal aspects of statistical activities; cost accounting; research; simplified practice and industrial standardization; public, trade and employer-employee relations; credit and insurance departments, and traffic and transportation service bureaus. The industries covered are construction, railways and public utilities, automobiles, airplanes and highways, mining and oil, metals and machinery, textiles and clothing, farm products, banking and insurance, and wholesale and retail trade.

Tests Made of Car Lighting. By W. R. Cost. Published in *Aera*, March, 1928, p. 137. [H-4]

Of 120 votes cast to indicate preference for one of four car-lighting systems shown at the 46th annual convention of the American Electric Railway Association, 79 were lumped in favor of one system. This consisted of five 12-in. ceiling-type, inclosing-hemisphere fixtures, each unit containing lamps totaling 200 watts. The inclosing-bowl fixtures were spaced at 8-ft. intervals on the longitudinal center line of the car. Medium-density deep bowls and light-density shallow bowls of the diffusing type were exhibited with this system.

The systems are here described, the arrangements for the lighting outlets are shown, and the illumination provided by each on the 45-deg. reading plane at all seats is given. Candle-power distribution curves of the lighting units are also presented.

Profitable Application of Electric Industrial Trucks and Tractors in Industry. By H. J. Payne. Published by the Society for Electrical Development, Inc., New York City. 89 pp. [H-5]

. If, as is said, the average plant spends 80 cents for intramural transportation to match every dollar spent for freight movement outside the factory walls, certainly goods movement within factory walls is a subject worthy of intensive study by industry. The case of the automotive industry is perhaps even more serious, for in statements quoted 90 per cent of the total manufacturing effort is assigned to materials handling.

The case for one type of carrying equipment is presented in this booklet, which describes various electric industrial trucks and tractors used in 19 different industries and cites the results obtained with them. The flexibility of these vehicles is forcefully brought home. For their cost and durability the following claims are made:

(*Continued on p.* 38)

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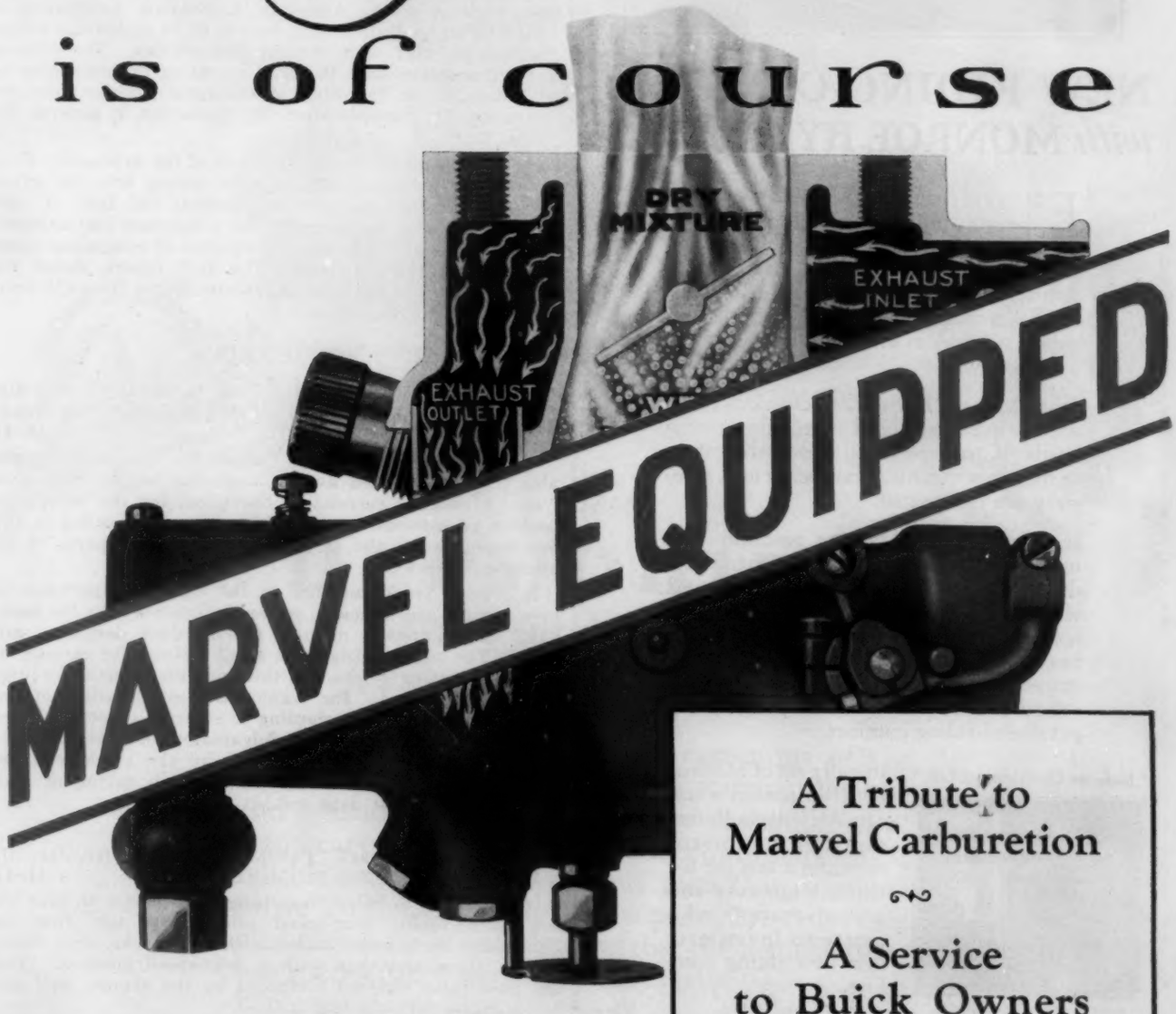

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MONROE HYDRAULIC SHOCK ELIMINATORS

Notes and Reviews

Continued

For practical purposes the net outlay involved in making the change is written off within the first year of operation; further, earnings are made over a long period—it is conservative to say that 90 per cent of the equipment installed during the past 20 years is still operating.

MOTORCOACH

Bus Division Completes First Study of Operating Cost Data. Published in *Operation & Maintenance*, Feb. 15, 1928, p. 18. [J-4]

From 24 to 26 cents per motorcoach-mile is not an unusually low cost for intercity operation. This opinion of the Bus Division of the American Automobile Association is based on an analysis of cost figures of 30 companies which, on June 30, 1927, were running 980 vehicles. The division further estimates that the total operating expenses may be allocated in the following percentages: maintenance, 30; operation, 24; transportation, 25; promotion, 3; general, 15; taxes, 3.

A detailed tabulation is presented of the expenses. Four noteworthy points revealed by the survey are: the great variation in the depreciation charged; the lack of uniformity in taxes; the necessity for a standard cost-accounting system, and the increasing number of companies operating on a profitable basis. The next report, slated for release in July, is expected to contain figures from 150 companies.

MOTOR-TRUCK

Motor Truck and Light Cars Used to Dismantle 165-Mile Railway. By T. E. Rust. Published in *Engineering News-Record*, Feb. 23, 1928, p. 328. [K-4]

To the *veni, vide, vici* of Caesar, the automobile might also add, "and carted away," according to the story here told. A railroad suspending operation, for the most part because of automobile and truck competition, called in the motor-vehicle for the salvaging of the metal parts of its abandoned tracks.

A 2½-ton truck, modified in the light of experience to meet certain special needs, proved satisfactory for the haulage. The practical detailed specifications developed are listed. The author designed a small rail-car for cartage to the truck-loading points, and this and other pieces of equipment are described. The organization and handling of the personnel for this job, according to evidence presented, were also carefully worked out. Advantages of both convenience and cost were demonstrated by the truck, and its superiority over the locomotive for such salvaging was shown. A few cost data are set forth.

Three Speeds or Four? Published in *The Motor*, Jan. 31, 1928, p. 1314. [L-1]

In the effort to bring some tangible evidence to bear on the three versus four-speed controversy, test runs of 2000 miles each were made in the same car, first fitted with a three and then with a four-speed gearbox. The top gear ratio was not disturbed by the change, and the bottom ratio only slightly.

During the tests observations were made on the maximum and average speeds obtainable, ease of handling and fuel consumption. Acceleration curves showing the intermediate speeds, the time consumed and the space covered in reaching a given speed with the three and four-speed gearboxes are also given.

The conclusion drawn is that with a modern power unit of moderate capacity four forward speeds are desirable, provided that the driver will make full use of the gearbox.

(*Concluded on p. 42*)

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Notes and Reviews

Continued

PASSENGER-CAR

How Henry Ford's Material Control Reduces Production Costs. By John Younger. Published in *Manufacturing Industries*, February, 1928, p. 95. [L-5]

Price control is not solely, perhaps not even primarily, the incentive of the Ford policy of raw-material supply. The author of the present article, one of a series to treat of basic principles of manufacture that are applied in all Ford industries, selects inventory control as the major factor. Particularly is this purpose served since the reins of transportation as well as of the sources of production are held by the Ford interests. Mr. Ford is said particularly to deprecate speculation in raw materials.

Keeping in strict order material in transit, maintaining a fluid flow of finished as well as unfinished inventory, and reducing the distances materials have to be moved during production are other expedients of efficiency mentioned. Some unusual methods of saving in the production of raw materials are also touched on.

Some Notes on Reorganizing a Works to Increase Production. By C. R. F. Engelbach. Preprint of paper presented before the Institution of Automobile Engineers. Published by the Institution of Automobile Engineers, London, England. 19 pp.; 19 illustrations. [L-5]

A factory reorganization is here described that, in the course of the last 6 years, accomplished the following results: increased the turnover, profit volume, number of employes and average earnings by the following respective percentages, 504.7, 432.9, 328.8 and 72.0; and decreased the selling price to the purchaser 62.0 per cent and the number of employes per car per week from 55 to 10.

The company that accomplished this is the Austin Motor Co., which altered and rearranged its plant while maintaining continuous production and making radical changes in the design of its product.

The Great Four-Ring Battle of 1928. By James Dalton. Published in *Motor*, January, 1928, p. 72. [L-6]

A definite forecast of automotive sales for 1928 made in this article is based on current data, an analysis of buying trends as indicated in the past, and suppositions as to immediate future general economic conditions.

The contest, the author believes, will center in four price-classes below $2,000. Total sales are estimated at 3,850,000 to 4,000,000 cars, in the following price classes: under $660, 1,750,000 to 1,800,000; $661 to $1,000, 1,000,000 to 1,050,000; and over $1,000, 1,100,000 to 1,150,000.

TRACTOR

Automotive Equipment and Development. By Levin H. Campbell, Jr. Published in *The Military Engineer*, January-February, 1928, p. 6. [M-1]

The entry of this Country into the World War, and the consequent immediate requirement for large numbers of tractors, tanks and other special automotive equipment brought the Ordnance Department into the field of automotive design. The intensity of experimental work and the variety of expedients resorted to in meeting requirements under the pressure of war stress and subsequently sustained under this impetus are pictured in this account.

Charged particularly with the supply of automotive vehicles adapted to cross country locomotion, the Ordnance Department has specialized on the development of various types of tractor, creeper-track truck and tank. Among the tractors here described are 2½, 5 and 10-ton vehicles. The cross country cars include modified Ford, Chevrolet and Citroen models. Cargo carriers are of both the self-propelled and the trailer types. Since the armistice, efforts along the lines of tank development have been devoted to attainment of higher speeds than were possible with the war-time products. Motor carriages for both the transportation and firing of guns have also been the subject of design and experiment.